California High-Speed Train Project

Request for Proposal for Design-Build Services

RFP No.: HSR 11-16
Floodplain Impacts Assessment and Hydrology & Hydraulics Report
Ave 17 to South of Santa Clara St

Prepared for

CALIFORNIA High-Speed Rail Authority

CALIFORNIA HIGH-SPEED TRAIN

Engineering Report

Procurement Package 1
Proposed Preliminary Design

Floodplain Impacts Assessment and Hydrology & Hydraulics Report

February 2012

CALIFORNIA
High-Speed Rail Authority

U.S. Department of Transportation
Federal Railroad Administration

CALIFORNIA HIGH-SPEED TRAIN PROJECT

ENGINEERING REPORT

Procurement Package 1
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Floodplain Impacts Assessment and Hydrology & Hydraulics Report

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February 06, 2012

California High-Speed Rail Authority and Federal Railroad Administration. 2011. *Procurement Package 1 Floodplain Impacts Assessment and Hydrology & Hydraulics Report, California High-Speed Train Project*. Sacramento, CA, and Washington, DC. Prepared by AECOM, CH2M HILL, Arup, URS Corp., and Hatch Mott MacDonald, January 2012.

Table of Contents

Tables

Figures

Appendices

Abbreviations

ASTM	American Society of Testing and Materials
Authority	California High-Speed Rail Authority
base flood	FEMA regulatory 100-year flood
Bay Area	San Francisco Bay Area
BFE	base flood elevation
Caltrans	California Department of Transportation
CCR	California Code of Regulations
CDFG	California Department of Fish and Game
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CVFPB	Central Valley Flood Protection Board
CVFPP	Central Valley Flood Protection Plan
CWA	Clean Water Act
CWC	California Water Code
CWD	Chowchilla Water District
DWR	California Department of Water Resources
FEMA	Federal Emergency Management Agency
FID	Fresno Irrigation District
FIRM	Flood Insurance Rate Map
FIS	flood insurance study
FMFCD	Fresno Metropolitan Flood Control District
FRA	Federal Railroad Administration
GIS	geographic information system
H:V	horizontal:vertical
ID	identifier
HDPE	high-density polyethylene
HMF	heavy maintenance facility
HST	high-speed train
NFIP	National Flood Insurance Program
O&M	operations and maintenance
Draft Project EIR/EIS	*Merced to Fresno Section High-Speed Train Project EIR/EIS*
PVC	polyvinylchloride
RGRCP	rubber gasket reinforced concrete pipe
SPFC	State Plan for Flood Control
USACE	United States Army Corps of Engineers
U.S.C.	United States Code
USGS	U.S. Geological Survey
WSE	water surface elevation

1.0 Introduction

1.1 Purpose

This Floodplain Impacts Assessment Report was prepared for water crossings located between Herndon Avenue and just south of Santa Clara Street in the City of Fresno. The purpose of this report is to accomplish the following:

- Summarize the regulatory framework pertaining to project floodplain encroachments.
- Summarize hydrologic and hydraulic design requirements for bridges and culverts.
- Identify the primary water crossings within the reach.
- Summarize preliminary hydrologic and hydraulic data and analyses that support conceptual-level water-crossing designs.
- Describe conceptual-level water-crossing hydraulic designs.
- Identify additional analyses and permits that will be needed as design progresses.

This report is specific to floodplain encroachments and water crossings. It does not address stormwater, groundwater, water quality, or other broader water resource regulations governing the project.

1.2 Project Description

1.2.1 California High-Speed Train Project

The California High-Speed Train (HST) Project includes approximately 800 miles of new HST guideway and numerous related heavy maintenance facilities and stations. The purpose of the HST Project is to provide the public with electric-powered high-speed rail service that provides predictable and consistent travel times between major urban centers and connectivity to airports, mass transit systems, and highway networks. The project follows existing transportation corridors, where practical, to minimize impacts on existing land uses while connecting the extended metropolitan areas of San Francisco, Los Angeles, and San Diego; and Central Valley communities, including Sacramento, Stockton, Merced, Fresno and Bakersfield.

The HST alignment must safely accommodate an HST speed of up to 220 miles per hour (mph). To maintain these speeds and a comfortable ride, horizontal and vertical curves must be gradual. The guideway must also be isolated from animals, pedestrians, and vehicles to avoid collisions. There must be a grade separation from all intersecting roads, railroads, walkways, trails, and throughways. Limitations on at-grade crossings and curve radii prevent the horizontal and vertical alignments from being constructed exactly parallel to existing transportation features at some locations, and limit the angle and location at which floodplains and waterbodies are crossed.

1.2.2 Procurement Package 1

In the Central Valley, the HST Project was originally broken into three primary sections—Merced to Sacramento, Merced to Fresno, and Fresno to Bakersfield—each assigned to a regional consulting team. As part of the American Recovery and Reinvestment Act of 2009 (ARRA), funding was obtained to begin early construction of an Initial Construction Section (ICS) that covers a contiguous portion of the Merced to Fresno Section and the Fresno to Bakersfield Section. The ICS was divided into four construction phases. The first phase has been committed to be built, is referred to as Procurement Package 1 and extends from roughly Herndon Avenue in the north to just south of Santa Clara Street. The approximate limits of Procurement Package 1 (committed to build) are shown on Figure 1-1. The optional segment of the ICS is divided into BNSF Option 1 and

UPRR Option 2 which are defined and discussed in the Merced to Fresno Section 15% Final Design Submittal Hydraulics and Floodplain Technical Report (Authority and FRA 2011b).

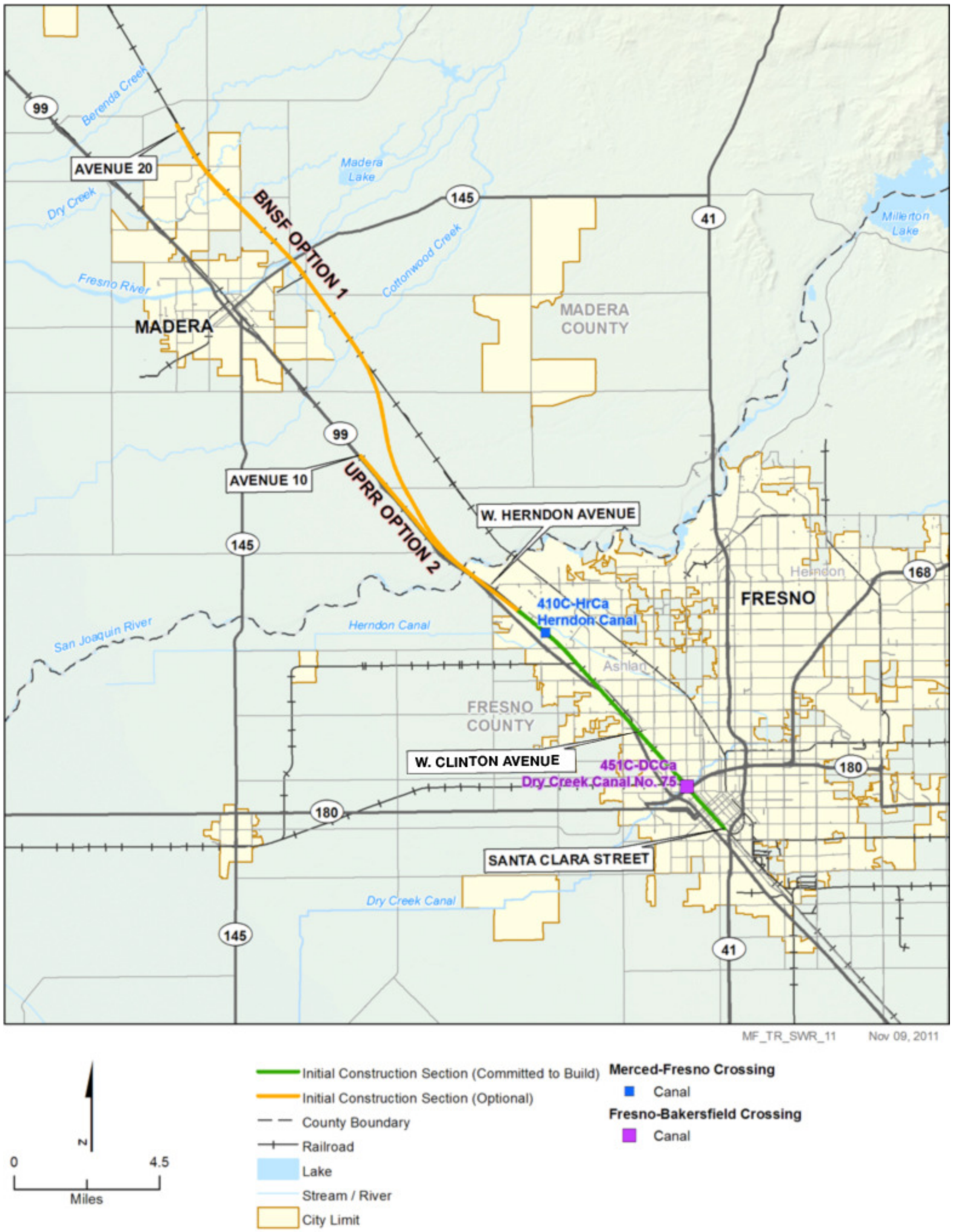

Figure 1-1
Initial Construction Section Limits and Alignments

1.3 Limitations

Content, analyses and conclusions presented in this report are preliminary, consistent with concept-level design. They are provided as an aid to the project designer. They are not a substitute for the design-builders' own analyses. The design-builder is responsible for verifying regulatory requirements and for carrying out independent engineering design and calculations that meet these requirements for all required permits.

2.0 Regulatory Framework

2.1 Introduction

This section provides an overview of federal, state, and local regulations that pertain to HST floodplain encroachments and water crossings.

2.2 Federal Regulations

2.2.1 Rivers and Harbors Act

A. Protection of Improvements to Navigable Waters (Title 33 Section 10 of USC Section 401)

Section 10 of the Rivers and Harbors Act (Title 33 United States Code [USC] Section 401), administered by the U.S. Army Corps of Engineers (USACE), requires permits for all structures constructed in navigable waters of the United States including pilings, docks, and bridges. Excavation or fill activities such as dredging and placement of fill or riprap in the waterways also require permits. Navigable waters include waters that are subject to the ebb and flow of the tide and rivers used as a means of interstate transport or foreign commerce. USACE grants or denies permits based on the impacts on navigation. Section 404 of the Clean Water Act (CWA) also covers most of these activities (see below).

B. Use of Harbor or River Improvements (Title 33 USC Section 408)

Title 33 of the USC Section 408 defines the responsibilities of USACE for regulating modifications to federal flood-control projects. Modifications, such as realignments, changes in flood capacity or structural impacts to levees, require USACE approval via a Section 408 permit. Section 408 specifies the technical and risk analyses that must be submitted to USACE by any non-federal sponsor of a project that may adversely affect the capacity or structural integrity of a federal flood control facility. The types of information required include detailed structural information, hydraulic data (e.g., water surface profiles), and geotechnical evaluations (e.g., levee seepage and stability). A memorandum, *Clarification Guidance on the Policy and Procedural Guidance for the Approval of Modifications and Alterations of Corps of Engineers Projects* (USACE 2008), provides detailed information.

C. Local Flood Protection Works (Title 33 CFR Section 208.10)

Title 33 of the Code of Federal Regulations (CFR) Section 208.10 defines the responsibilities of USACE for maintenance of flood channels, levees, and other flood protection features constructed by the federal government. Section 208.10.a.5 defines the responsibility for assuring that projects or other improvements are constructed in a manner that does not reduce the capacity or functionality of any federal flood control project.

USACE approval may be granted under Section 208.10 for alterations or improvements that have little or no impact on the authorized level of protection (capacity) and structural integrity of a federal flood protection project. The Central Valley Flood Protection Board (CVFPB), which is part of the California Department of Water Resources (DWR) (formerly the California Reclamation Board), administers Section 208.10 in the Central Valley. CVFPB administers permits for encroachments on state and state–federal flood control projects. USACE provides a concurrent review of the technical aspects of encroachment permit applications, and provides to CVFPB a list of technical requirements to satisfy USACE responsibilities under Section 208.10.

2.2.2 Clean Water Act

A. Section 404 Permit for Fill Material in Waters and Wetlands

The CWA Section 404 regulates the discharge of dredged and fill materials into waters of the United States, which include oceans, bays, rivers, streams, lakes, ponds, and wetlands. Emphasis is placed on protection of water quality and conservation of marine and aquatic habitat. Projects are encouraged to avoid impacts on waterbodies or to minimize impacts where a waterbody cannot be avoided. Projects mitigate for lost habitat, typically by providing replacement habitat at a different location. A 404 permit application must be submitted to USACE. Nationwide 404 permits exist for a large number of activities that have been determined to cause generally minor impacts. A single application typically covers the requirements of both Section 10 (Rivers and Harbors Act) and Section 404 (CWA).

B. Section 401 Clean Water Quality Certification

Under CWA Section 401, applicants for a federal license or permit to conduct activities that may result in the discharge of a pollutant into waters of the United States must obtain certification from the state in which the discharge would originate, or, if appropriate, from the interstate water pollution control agency with jurisdiction over affected waters at the point where the discharge would originate. Therefore, all projects that have a federal component and may affect the quality of state waters (including projects that require federal agency approval, such as issuance of a Section 404 permit) must also comply with CWA Section 401. Section 401 certification or waiver is under the jurisdiction of the applicable regional water quality control board.

2.2.3 Executive Order 11988 – Floodplain Management (U.S. Department of Transportation Order 5650.2)

Executive Order (EO) 11988 directs all federal agencies to (1) avoid to the extent practicable and feasible all short-term and long-term adverse impacts associated with floodplain modification and (2) avoid direct and indirect support of development within 100-year floodplains when there is a reasonable alternative. Additional specific information must support projects that encroach on 100-year floodplains. The U.S. Department of Transportation Order 5650.2, *Floodplain Management and Protection,* prescribes "policies and procedures for ensuring that proper consideration is given to the avoidance and mitigation of adverse floodplain impacts in agency actions, planning programs and budget requests." The order does not apply to Zone C (areas of minimal flooding) as shown on Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs). Environmental review documents should indicate potential risks and impacts from proposed transportation facilities.

2.2.4 Flood Disaster Protection Act (Title 42 USC 4001 et seq.)

The purpose of the Flood Disaster Protection Act is to identify flood-prone areas and provide insurance. The act requires the purchase of insurance for buildings in special flood-hazard areas. The act is applicable to any federally assisted acquisition or construction project in an area identified as having special flood hazards. Projects should avoid construction in, or develop a design to be consistent with, FEMA-identified flood-hazard areas.

FEMA oversees the National Flood Insurance Program (NFIP). NFIP offers federally backed flood insurance to homeowners, renters, and business owners in communities that choose to participate in the program. Typically, each county has a flood insurance study (FIS). Within the study area, the latest FISs include Fresno County (FEMA 2009).

FEMA and participating communities work together to develop FIRMs. The FIRMs delineate flood hazard zones. Flood hazard zones are areas inundated by the base flood, which has a 100-year recurrence interval (i.e., 1% chance of annual flooding and 26% chance of flooding over a 30-year period). Flood hazard zones are further classified by the hydraulic modeling approach and the level of detail used in delineating the base flood boundaries and elevation. Flood hazard zone classifications are defined in Table 2-1.

Table 2-1
Flood Hazard Zones

Zone	Description
A	Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. Because detailed analyses are not performed for such areas, no depths or Base Flood Elevations (BFEs) are shown within these zones.
AE	The base floodplain where BFEs are provided. AE zones are now used on new format FIRMs instead of A1–A30 zones.
A1 through A30	These are known as numbered A zones (e.g., A7 or A14). This is the base floodplain where the FIRM shows a BFE (old format).
AH	Areas with a 1% annual chance of shallow flooding, usually in the form of a pond, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over the life of a 30-year mortgage. BFEs derived from detailed analyses are shown at selected intervals within these zones.
AO	River or stream flood hazard areas and areas with a 1% or greater chance of shallow flooding each year, usually in the form of sheet flow, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Average flood depths derived from detailed analyses are shown within these zones.
AR	Areas with a temporarily increased flood risk due to the building or restoration of a flood control system (such as a levee or a dam). Mandatory flood insurance purchase requirements apply, but rates do not exceed the rates for un-numbered A zones if the structure is built or restored in compliance with zone AR floodplain management regulations.
A99	Areas with a 1% annual chance of flooding that will be protected by a federal flood control system where construction has reached specified legal requirements. No depths or BFEs are shown within these zones.
BFE = base flood elevation	

In some reaches (zone AE), hydraulic modeling has been used to determine the inundation limits of the base flood on the FIRM, and the FIRM shows within these limits the boundaries of a floodway. The floodway is that portion of the 100-year floodplain in which, based on prior modeling, encroachment would result in greater than a 1-foot water surface elevation rise at any location. Encroachments are excluded within the floodway unless a registered civil engineer certifies, based on modeling, that the base flood elevation (BFE) will not rise.

To be eligible for federally backed flood insurance, a community must participate in the NFIP. Participating communities must adopt and enforce floodplain management ordinances that meet or exceed FEMA requirements for reducing the risk of future flood damage. FEMA has set a minimum national standard, allowing no more than a 1-foot increase in BFEs (whether mapped or not mapped) because of the cumulative impact of local development. The participating FEMA communities in the study area are discussed later in this section. Each of those communities has adopted the FEMA 1-foot-maximum-rise criteria.

If a project will substantially alter the extent or depth of the base flood, the project owner must submit supporting documentation and modeling. If FEMA approves the development proposal, they issue a Conditional Letter of Map Revision. After construction is complete, as-built construction plans and modeling are submitted to FEMA, and FEMA issues a Letter of Map Revision, which officially updates the FIRM.

2.3 State Regulations

2.3.1 CCR Title 23, Division 1

California Code of Regulations (CCR) Title 23 details regulatory authority for the CVFPB. In cooperation with USACE, the CVFPB provides policy direction and coordination for the flood control efforts of state and local agencies along the Sacramento and San Joaquin Rivers and their tributaries. CVFPB cooperates with federal, state, and local government agencies in establishing, planning, constructing, operating, and maintaining flood control works. By issuing permits for encroachments, CVFPB also exercises regulatory authority to maintain the integrity of the existing flood control system and designated floodways.

CVFPB has mapped designated floodways along more than 60 streams and rivers in the Central Valley. CVFPB *designated floodways* are different from FEMA *floodways.* CVFPB-designated floodways are within the designated flood boundaries for the designated project flow rate and are similar in meaning to the FEMA base flood boundaries shown on FIRMs. In addition to designated floodways, Table 8.1 in Title 23 CCR lists several hundred stream reaches and waterways as regulated streams. Projects that would encroach on a designated floodway or regulated stream, or come within 10 feet of the toe of a state–federal flood control structure (e.g., a levee), require an application (with an associated environmental assessment questionnaire) for an encroachment permit.

Title 23 (Waters), Volume 32 of the CCR provides CVFPB regulations and detailed lists of standards that must be met for an encroachment permit. USACE (at the district level) reviews encroachment permits to monitor conformance with 33 CFR Section 208.10. Title 23 restricts CVFPB jurisdiction to crossings of an *adopted plan of flood control*. Title 23 defines an *adopted plan of flood control* as a flood control or reclamation strategy for a specific area that has been adopted by CVFPB or the California Legislature. The term typically applies to the area between adopted flood boundaries, such as a designated floodway, the channel and floodplain inundation area for a non-leveed state–federal flood control project, or the area between the outer boundaries of state–federal flood-control project levees.

In 2011, CVFPB indicated that its jurisdiction is broader than that described in Title 23, and extends to all tributaries of the San Joaquin and Sacramento Rivers; that all named tributaries require an encroachment permit (Taras and Tice 2011). The CVFPB also indicated that all canals that carry flood flows are now jurisdictional and require an encroachment permit (Taras 2011a). A new state tool can be used to help identify canals with designated flood flows: http://gis.bam.water.ca.gov/bam/.

This inclusion of all named tributaries and flood-carrying canals as jurisdictional crossings is based on the California Water Code Section 8710. Note that this expanded list of jurisdictional crossings is a recent change to previous direction, and has not been fully formalized in writing by the CVFPB. At this time, the final interpretation of which crossings require an encroachment permit is not known.

CVFPB reviews applications for an encroachment permit for completeness and works with the applicant to ensure that all required application content is submitted (Taras 2010; Larson 2010). CVFPB provides a copy of the application to USACE for concurrent review. In general, USACE focuses on technical engineering requirements, such as hydraulic modeling, geotechnical studies, and performance requirements to fulfill its obligations under Section 408 and Section 208.10 (refer to Section 2.2.1); CVFPB focuses on environmental compliance and Title 23 standards to ensure compliance under the California Environmental Quality Act (CEQA) and Title 23. USACE develops a list of requirements and restrictions (e.g., maximum rise criteria demonstrated through hydraulic modeling), which append the permit. CVFPB may also develop a list of requirements and restrictions for the permit and either issue the permit with requirements and restrictions or deny the permit based on their collaborative review with USACE.

2.3.2 CCR Sections 1601–1603 – Streambed Alteration

The California Department of Fish and Game (CDFG) is responsible for, among other things, preserving and protecting aquatic and marine habitats. Under Sections 1601–1603 of the California Fish and Game Code, agencies are required to notify CDFG prior to implementing a project that would substantially divert, obstruct, or change the natural flow of any river, stream, or lake. The project proponent must notify CDFG about any action that would substantially alter the channel or streambed or deposit material within the channel. The project proponent must submit a Notification of Lake or Streambed Alteration. If CDFG determines that the project may adversely affect an existing fish and wildlife resource, they will issue a Lake or Streambed Alteration Agreement that lists measures that adequately protect the resource.

2.3.3 Central Valley Flood Protection Act

DWR and CVFPB (which is part of DWR) are currently collaborating with local governments and planning agencies to prepare and adopt the Central Valley Flood Protection Plan (CVFPP) by mid-2012. The objective of CVFPP is to create a system-wide approach to flood management and protection improvements in the Central Valley (Sacramento Valley and San Joaquin Valley).

The CVFPP is a requirement of the Central Valley Flood Protection Act of 2008, which establishes the 200-year flood event as the minimum level of flood protection in urban and urbanizing areas. An urban area is any contiguous area in which more than 10,000 residents are protected by project levees (Public Resources Code 5096.805). Cities and counties must amend their general plans accordingly within 24 months of the CVFPP adoption; zoning ordinances must be amended within 36 months. Consequently, the 200-year flood event must be incorporated into city and county design standards by January 1, 2015 for new residential and nonresidential construction within flood hazard zones. By 2025, all urban areas protected by flood-control project levees must be protected from a 200-year flood event.

Under its FloodSAFE program, DWR is responsible for developing and making available maps for the 200-year floodplain (DWR 2008c). At this point, DWR has only released estimated boundaries for the new 200-year floodplain based on a preliminary study (DWR 2008d). CVFPB collaborates with cities and counties to develop policies for implementing amended general plans.

2.4 Local Regulations – Floodplain Development Permits

Local counties and/or cities in California participate in the NFIP and have adopted ordinances into their respective municipal codes that implement the community requirements for NFIP participation. Table 2-2 summarizes local ordinances with minimum floor elevation, floodproofing, and floodway encroachment for new construction.

Table 2-2
Key Components of Local Flood Ordinances

City or County	Municipal Code Section	Minimum Elevation Residential	Minimum Elevation Nonresidential	Nonresidential Floodproofing	Encroachment into Floodways
Merced County	Chapter 18.34	Constructed above flood elevation	All construction below the flood elevation to be floodproofed	Allowed	Allowed only if no increase occurs in flood elevation
City of Merced	Chapter 17.48	Constructed above flood elevation	Constructed above flood elevation	Allowed	Allowed only if no increase occurs in flood elevation
Madera County	Title 14, Chapter IV	Constructed above flood elevation	Constructed above flood elevation	Allowed	Allowed only if no increase occurs in flood elevation
City of Madera	See Merced County				
Fresno County	Chapter 15.48	Constructed 12 inches above flood elevation	Constructed 6 inches above flood elevation	Allowed	Allowed only if no increase occurs in flood elevation
City of Fresno	Chapter 11.6	Constructed 6 inches above flood elevation	Constructed 6 inches above flood elevation	Allowed	Allowed only if no increase occurs in flood elevation

In general, the finished floor elevation for nonresidential structures must be at or above the BFE. However, the finished floor can be constructed below flood elevation if it is floodproofed. Floodproofing is generally achieved if the structure is watertight, with walls substantially impermeable to the passage of water. In addition, the structural components must be capable of resisting hydrostatic and hydrodynamic loads and effects of buoyancy.

As indicated in the previous section, by the year 2015 DWR will require local ordinances to reflect a higher standard than required by FEMA in urban and urbanizing areas, effectively requiring local implementation of floodplain regulations for the 200-year base flood rather than the 100-year base flood required by FEMA.

2.5 Location Hydraulic Studies

Chapter 804 of the *Highway Design Manual* (Caltrans 2009) addresses the topic of floodplains; Section 804.7.2.e states that the results of *location hydraulic studies* must be summarized in the environmental document prepared for the project. A location hydraulic study is the preliminary investigation of the degree of floodplain encroachment by a state highway project (Caltrans 2009). The study must address the following:

- Flood risks associated with the project.
- Impacts on natural and beneficial floodplain values.
- Identification of probable incompatible floodplain development.
- Measures to minimize floodplain impacts.
- Measures to restore and preserve the natural and beneficial values affected by the project.

- Evaluation of the practicality of alternatives to significant floodplain encroachment.

In the same document, significant floodplain encroachment is determined by one or more of the following:

- A significant potential for interruption or termination of a transportation facility that is an emergency vehicle route or a community's only evacuation route.
- A significant risk to life or property.
- A significant adverse impact on the natural and beneficial floodplain values.

Section 804.7 of the *Highway Design Manual* states that the location hydraulic studies can be documented in a floodplain evaluation report attached to the project's environmental documentation. The timing of location hydraulic studies may depend in part on whether a state highway is being modified under Caltrans jurisdiction. Caltrans is not a direct reviewing agency for this project, except where the project impacts state highways (such as SR99); however, the California High-Speed Rail Authority (Authority) has generally agreed to comply with Caltrans requirements and templates, when practical.

3.0 Hydraulic and Hydrologic Assessments Required for Design and Permitting

3.1 Overview

Hydrologic and hydraulic information and modeling are required for design, endorsement by local maintenance agencies, and permitting (refer to Section 2). Permits potentially requiring hydraulic modeling include the following:

- Section 408 Permits, administered by the U.S. Army Corps of Engineers and approved at their headquarters. Conceptual designs have been configured in such a way that the designs should not trigger the requirement for a Section 408 Permit (see Section 2 and design requirements in Section 5). When the federal flood control project is not materially modified (by altering or encroaching on a levee, changing a channel alignment or adversely impacting the flood-control performance), crossing encroachments can be reviewed at the USACE district level under Section 208.10, administered by CVFPB via encroachment permits in the San Joaquin River and Sacramento River watersheds.

- Encroachment permits for waterways with an adopted plan of flood control, administered by CVFPB under Title 23 (see Section 3.2.1) and state–federal flood control project O&M manuals; and supported by USACE at the district level under 33 CFR 208.10.

- Local development permits that require conformance with local floodplain ordinances intended to support the FEMA National Flood Insurance Program and future DWR requirements pertaining to a 200-year base flood in urban and urbanizing areas.

- Location hydraulic studies attached to environmental documents.

The HST crosses waterbodies that have an adopted plan of flood control and FEMA floodplains; therefore, encroachment permits, local development permits, Caltrans location hydraulic studies, and borrow permits may be required, depending on the location. Anticipated permits requiring hydraulic analyses are summarized in Appendix A, Water Crossings and Floodplains. The project, including guideways and road or highway modifications, must be designed to limit hydraulic impacts at waterbody crossings and floodplains to satisfy regulatory requirements. Hydraulic modeling may be required to evaluate hydraulic impacts, conform to Title 23 design regulations, and demonstrate to USACE that a Section 408 permit is not required.

3.2 Encroachment Permits

3.2.1 Encroachment Permit Jurisdiction per Title 23

CVFPB is responsible for reviewing and approving all encroachment permits under Title 23 and California Water Code Section 8710. Preliminary direction by the CVFPB, consistent with Title 23, was that encroachment permits would be required for encroachments of three types of existing flood-control projects: leveed streams, designated floodways, and regulated streams. Each of these flood control projects are associated with a stage in the development of the CVFPB.

- **Leveed Streams:** The predecessor agency of CVFPB (the California Reclamation Board) was originally established to provide assurance that federal flood control projects constructed by USACE are operated and maintained (usually by a local levee maintenance agency) in accordance with the USACE O&M manuals prepared for the individual rivers.

- **Designated floodways:** Under the Designated Floodway Program, CVFPB can establish and delineate floodplains that it regulates, even when not originally part of a USACE flood control project. The Designated Floodway Program is CVFPB's primary nonstructural floodplain management program, with the purpose of controlling encroachments and unwise development within the floodplains of unleveed streams in the Central Valley.

- **Regulated streams:** In addition to regulating development in designated floodways, CVFPB also requires encroachment permits for development along regulated streams identified in Title 23. Regulated streams are distinguished from designated floodways in that there is no established floodway in regulated streams. The objective is to maintain existing flood capacity of stream channels by managing encroachments and obstructions that would hinder flood passage.

3.2.2 Expanded Jurisdiction per California Water Law Section 8710

During 2011, CVFPB described a broader jurisdiction based on California Water Law Section 8710. Under this interpretation, CVFPB jurisdiction extends beyond Title 23 to include the following:

- **Tributaries and Distributaries:** all tributaries and distributaries of the San Joaquin River and the Sacramento River. Early direction is that encroachment permit applications should be submitted for "every named slough" that the HST Project crosses within these two watersheds, but that "unnamed trickle creeks" will not require encroachment permits (Taras and Tice 2011).

- **Irrigation Canals with Flood Conveyance:** Encroachment permit applications should also be submitted for canal crossings if the canal has a recognized use for flood conveyance, such as a recognized FEMA floodplain (Taras 2011b). According to Curt Taras of CVFPB, "If a channel is used for flood conveyance then it affects the State plan of flood control and under our jurisdiction." CVFPB has provided a website to help with identification of official floodplains from various agencies, including FEMA: http://gis.bam.water.ca.gov/bam/.

3.2.3 Multiple Crossings

In some cases the HST may cross a single jurisdictional waterbody multiple times. In these cases, a separate permit is required for each individual crossing because the crossings are separated. However, where the alignment crosses a cluster of points in a waterway because of a meander, only one permit application is required (Taras 2010). The precise number and location of encroachment permits required will depend on negotiations with CVFPB over exactly which crossings require a permit.

3.2.4 Approach for Obtaining Encroachment Permits

Application for encroachment permits occurs after initial consultation with CVFPB for individual crossings, typically when the design is approximately 60% or more complete. Applications must be completed by using the encroachment permit application form at the end of Title 23. CVFPB reviews applications for an encroachment permit for completeness and works with the applicant to ensure that all required application content is submitted (Taras 2010; Larson 2010). CVFPB provides a copy of the application to USACE for concurrent review. In general, USACE focuses on technical engineering requirements, such as hydraulic modeling, geotechnical studies, and performance requirements to fulfill its obligations under Section 408 and Section 208.10 (refer to Section 2.2.1); CVFPB focuses on environmental compliance and Title 23 standards to ensure compliance under CEQA and Title 23. Each permit application must include topographical and hydraulic data.

3.2.5 Letters of Endorsement

The local agencies responsible for the maintenance of levees within the area of the proposed work must endorse encroachment permit applications before submitting the applications to CVFPB. This includes irrigation districts and local levee maintenance agencies. In Fresno, the endorsement would come from the Fresno Irrigation District (FID). In addition to FID endorsement, flood-carrying canals would also need endorsement from the Fresno Metropolitan Flood Control District (FMFCD).

A formal letter of endorsement is not required; instead, the application form can be signed to indicate endorsement or withholding of endorsement. Additional information can be included in a letter and submitted with the application.

If the application is not endorsed or endorsement is unreasonably delayed, the application can be submitted without the endorsement with a satisfactory explanation. CVFPB then considers whether the endorsement was unreasonably withheld.

3.3 Floodplain Development Permits

3.3.1 Base Flood

The FEMA base flood is the 100-year flood. California has adopted a new standard for base flood events for urban and urbanizing areas in the Central Valley, requiring protection from the 200-year flood event (see Section 2.3.3). DWR is still in the process of defining the new 200-year discharge and floodplain under its FloodSAFE program (DWR 2008c; Taras 2011b). CVFPB has provided direction that original 200-year hydrology should be developed by the HST Project consultants without waiting on the DWR (Taras 2011b). It is anticipated that the 200-year original hydrology will need to be developed by the design-builder; however the Authority will provide final direction on this issue. Reaches that qualify as "urban or urbanizing" have not been delineated by DWR.

3.3.2 Development Permits

Local floodplain development permits are required to demonstrate that requirements for base floor elevations, floodproofing, and floodway encroachments are met (see Section 2.4).

Development permits must be obtained before any construction or development within a special flood hazard zone can begin. To apply for a development permit, all other required state and federal permits must be obtained prior to the permit review. This includes all appropriate encroachment permits. However, encroachment and local development permit applications and the associated hydrologic and hydraulic analysis can be completed in parallel. Encroachment permits require endorsement of the conceptual design by local agencies, including cities and levee and irrigation districts, prior to review by CVFPB.

Development permit applications are obtained through the appropriate municipalities. Typical permits require the following information (Fresno County Ordinances, Chapter 15.48.060, Flood Hazard Areas Administration):

1. Plans in duplicate, drawn to scale, showing the following:
    a. Location, dimensions, and elevation for the area in question, existing or proposed structures, storage of materials and equipment, and their location.
    b. Proposed locations of water supply, sanitary sewer, and other utilities.
    c. Grading information showing existing and proposed contours, proposed fill, and drainage facilities.
    d. Location of the regulatory floodway when applicable.
    e. BFE obtained from the appropriate local FIS. Where not available, the BFE must be estimated by using local studies or in accordance with *Managing Floodplain Development in*

Approximate Zone A Areas: A Guide for Obtaining and Developing Base (100-Year) Flood Elevations (FEMA 1995).

f. Proposed elevation, in relation to mean sea level, of the lowest floor (including basement) of all proposed structures.

g. Proposed elevation in relation to mean sea level to which a proposed nonresidential structure would be floodproofed according to the local floodplain ordinance.

2. Certification by a registered civil engineer or architect that the proposed nonresidential floodproofed building meets the local flood proofing criteria.

3. Description of the extent to which any watercourse would be altered or relocated as result of proposed development.

To establish the minimum water surface elevation (WSE), project profile and grading requirements at a crossing, the appropriate local FEMA FIRM should be consulted to determine whether the BSE WSE has been mapped. Whether or not the FIRM indicates actual elevations, a local hydraulic study must generally be carried out to demonstrate an acceptably small incremental rise as a result of the HST Project crossing design. In general, canals with flood conveyance will not have FEMA BFEs, and many or most of the FEMA FIRMs in the Central Valley show only approximate floodplain depths without specific WSEs. An exception is the San Joaquin River, where BFEs have been determined.

3.4 Location Hydraulic Studies

Location hydraulic studies must be performed for each of the major stream crossings to support environmental permitting and local development permits. The following should be determined and developed for all applicable waterbodies identified in Appendix A, Water Crossings and Floodplains:

- WSE based on the 100-year design flow (or potentially the 200-year design flow in an urban area).
- A map illustrating the FEMA 100-year flood limits (or potentially the DWR 200-year floodplain limits) and portions of the project and existing buildings situated within the floodplain.
- Completion of Caltrans Forms 804.7A (Technical Information for Location Hydraulic Study) and 804.7B (Floodplain Evaluation Report Summary) for projects identified to have minor floodplain impacts (Section 804 of the *Highway Design Manual* [Caltrans 2009]).

3.5 Hydrologic Information

3.5.1 Existing Hydrologic Information

When available, existing hydrologic design flows are summarized in Appendix B, Hydrologic Design. Preliminary research and interviews were conducted to determine what hydrologic information is currently available and to assess the quality of that information. The base or design flow is the most important hydrologic information needed to perform the appropriate hydraulic analyses to support permitting efforts. Where possible, it is preferred to use existing design floods and peak-discharge flow rates rather than developing new hydrologic models. The following were inventoried for hydrologic information:

- USACE O&M manuals for state–federal flood control projects.
- CVFPB Designated Floodway Program documents.
- Local FISs.
- DWR Best Available Maps.

- Caltrans hydrologic records.
- Irrigation district design flows.
- USACE Comprehensive Study (USACE 2002) and ongoing FloodSAFE Program.
- Local county and municipal records.

The references section includes the sources used for this inventory. CVFPB supplied the 100-year peak discharges for designated floodway crossings (CVFPB Designated Floodway Program Table, September 1990, including San Joaquin River, Fresno River, Chowchilla River, Ash Slough, and Berenda Slough, among others). These design flows match the capacities provided in the USACE O&M manuals.

3.5.2 Additional Work for Hydrology

Hydrologic information is available for many of the HST Project water crossings (see Appendix A, Water Crossings and Floodplains); however, in some cases this data may be several decades old. Curt Taras of CVFPB has indicated that new, original hydrology should be developed for all of the natural waterbody crossings, including 200-year design flows where anticipated to be the future base flood standard under California law. He also indicated that available hydrologic information, including FEMA flow rates and flood control project designated design flow rates that are more than about 15 years old, are generally not adequate for either design or encroachment permits (Taras 2011b). The Authority will be holding meetings with CVFPB to further resolve the scope of additional hydrology work across the project. Further discussion with the CVFPB may be appropriate on a case-by-case basis for specific crossings.

3.6 Hydraulic Information

3.6.1 Existing Hydraulic Information

Preliminary hydraulic information and modeling results are summarized in Appendix C, Hydraulic Design. Encroachment and local development permit applications require evaluation of the project hydraulic impacts to WSE, freeboard, channel stability (bottom and side slopes) and bridge scour (abutments and piers). Preliminary research was conducted to determine what hydraulic models and information are currently available and to assess the quality of that information. In some cases, hydraulic models were developed to support conceptual design. Hydraulic information was acquired from several sources, including survey data, FISs, irrigation districts, as-built drawings, existing hydraulic studies, and personal communications.

The FISs provide information regarding historical flooding. However, no historic high water marks or elevations are listed in the FISs that could be used for calibration purposes.

3.6.2 Additional Work for Hydraulics

Additional hydraulic modeling may be required to support detailed design of culverts, siphons, irrigation pipes and associated hydraulic appurtenances. Cross-section surveys and preliminary hydraulic models of waterways used for conceptual design of this project will be made available by the Rail authority for subsequent design refinements.

4.0 Water Crossings

4.1 List of Waterbodies

Water crossings anticipated for this construction package are listed, mapped and described in Appendix A, Water Crossing and Floodplains. Water crossings potentially include natural waterways (streams, creeks and sloughs), canals (irrigation canals and ditches, and flood diversions canals), irrigation canals that are currently piped where they cross the project footprint, and culverts. Standing water features, such as vernal pools, wetlands and stormwater detention ponds; and utilities, such as municipal water supply pipelines and stormwater conveyance features, are not addressed in this report. Waterbodies are crossed by both the track alignment and the associated permanent project footprint, which includes new and repaved roads and other project features.

4.2 Water Crossing Identification Process

The inventory of water crossings was developed using data and information listed in Table 4-1.

Table 4-1
Information Sources for Waterbody Crossing Inventory

Data Source	Detail
National Hydrography Dataset High Resolution	Primary source
Irrigation District Maps	Fresno Irrigation District (2011)
Input from Irrigation District Personnel	Personal communication (Markups of spreadsheet lists and maps)
Aerial Imagery	Mapcon Mapping, Ltd. (2007)
Field Reconnaissance	In some cases, waterbodies were added, removed or named based on information recorded by team members performing site visits.

4.3 Preliminary Water Crossing Design Concepts

4.3.1 Conceptual Designs

Conceptual (30%) designs for each water crossing are summarized in Appendix A, Water Crossing and Floodplains. The design team selected preliminary horizontal and vertical alignments, as well as bridge and viaduct pier spacing, based on a number of considerations, with a view toward managing project costs.

4.3.2 Design Approaches

HST waterbody crossing designs can be broadly classified as culverts (circular conduits or concrete boxes), bridges (typified by an at-grade profile at the abutments and piers or large box culverts in the channel), or viaducts (both the HST approaches to the channel and the channel crossing itself are elevated on piers; this type is also known as an elevated crossing).

C. Culvert

Culverts are needed where new project embankments impede shallow floodplain flows or cross small, existing drainages and irrigation features such as private ditches, small canals and natural drainage swales. Culverts can range in size from relatively small-diameter pipe (minimum of 3 feet in diameter) to large precast concrete-box structures. Culverts can be single or placed in groups. Each culvert or set of culverts must be sized based on hydrologic (runoff) and hydraulic (capacity) modeling.

In the context of irrigation canals, culverts include pressurized pipes or inverted siphons used to pass water from an open canal headwork under the HST embankment and adjacent embankments. Where possible, a straight culvert is preferred to a U-shaped siphon, as straight culverts are easier to access and inspect for maintenance and potentially reduce sedimentation.

D. Bridge

When a total crossing length exceeds 20 feet, the Federal Highway Administration National Bridge Inspection Standards 23 CFR 650.305 define the structure as a bridge. Bridges typically have abutments placed in both streambanks to provide support. Hydraulic and environmental impacts typically are minimized when a bridge fully spans the waterbody; however, economics and practical limitations in span length may require supporting piers or columns within the channel. Environmental or hydraulic considerations can limit where bridge columns may be located.

E. Viaduct

For this type of crossing, the HST guideway is elevated above the ground surface, supported on columns. Column placement should be coordinated to avoid placement in narrow channels or levees.

4.4 Floodplains

Water crossing designs must accommodate designated floodplains. The *2012 Central Valley Flood Protection Plan – Regional Conditions Report* (DWR 2010) provides a summary of the hydrologic system of the Central Valley. The FEMA FISs by county summarize flood problems. Information from municipalities, flood control districts, and irrigation districts can also help identify local areas that are prone to flooding. The following types of floodplains are described in Sections 2 and 3. The approximate width of floodplains crossed is summarized in Appendix A, Water Crossing and Floodplains.

- State-Federal flood control project inundation limits (legislated design flow and return period)
- Designated floodway (designated by CVFPB or DWR)
- FEMA Base Floodplain (FEMA-approved design flow with 100-year return period)
- FEMA floodway
- DWR 200-year flood inundation limits (200-year return period) [DWR draft]
- Canal flood capacity (set by flood control district or irrigation district)

4.5 Non-Project Flood-Control Facilities

Non-project flood control facilities include levees and related facilities constructed by local agencies along natural waterways, as well as canals that have designated use for conveying floods. Embankments that form canals with above-grade flow profiles may periodically function as flood-control levees. Many of these facilities are operated and maintained similar to state-federal flood control project facilities, and may connect to them. By definition, non-project flood control facilities are not part of the State Plan for Flood Control (SPFC); however, the non-project levees affect the performance of the SPFC as part of the flood protection system.

4.6 Culverts

The crossings identified in Appendix A, Water Crossing and Floodplains, are not comprehensive with respect to cross-drainage culverts, existing or required. Preliminary culvert locations and concepts may need to be modified as private farmers decide to reroute or relocate their ditches to adapt to modified parcel configurations and access roads. Some smaller ditches may also be temporary, constructed or eliminated seasonally or depending on crop rotations, and may not need to be directly accommodated by the project.

4.7 Longitudinal Channel Impact

There may be locations where either the track right-of-way or portions of the permanent project footprint overlap longitudinal sections of natural and irrigation channels that parallel the project. Similarly, longer portions of a channel may be crossed by proximate crossings over an extended reach. In such cases, either the waterbody or project components should be evaluated for minor relocation to avoid overlap. To ensure track isolation safety, no active irrigation channels paralleling the guideway can remain within the fenced portion of the HST right-of-way.

5.0 Hydraulic Design Criteria

5.1 General

The hydraulic basis of design can be broadly divided into the following categories. Other regulations and categories may also apply.

- Design flow
- Flood capacity
- Protection of flood control structures
- Channel stability and scour control
- Borrow and excavation
- Pipelines, conduits, and utility lines
- Access
- Seasonal construction restrictions
- Other studies

Various agencies have regulatory responsibility to review HST project designs to ensure that they adequately satisfy design requirements in these areas. Table 5-1 summarizes selected design requirements and Figure 5-1 illustrates the requirements. The following sections describe design requirements more fully, including a sampling of design requirements in CCR Title 23. Title 23 should be reviewed for the full set of requirements. In some cases, variances to the design standards may be granted for good cause.

Table 5-1
Summary of Selected Hydraulic Design Requirements

No.	Design Consideration	USACE	CVFPB	Local Floodplain Ordinances (FEMA)	DWR Urban Areas	Irrigation Districts	California High-Speed Rail Authority
1	Basis of minimum design flow	Project Authorized	Project or Updated[3]	100-year	200-year[6]	Design	100-year or max regulatory
2	Minimum residual freeboard (ft)	3.0	2.0 to 4.0	--	--	1.0 to 2.0	2.0 or max regulatory
3	Minimum clearance above embankment (ft)	Negotiable: 0 to 18 ft; see Note 1	--	--	--	Negotiable: 0 to 16+ ft	--
4	Minimum setback from embankment toe (ft)	10 to 20 or zero; see Note 2	10+	--	--	Right-of-way	15
5	Minimum clearance above bottom of channel (ft)	--	--	--	--	8	--
6	Maximum flood water surface rise (ft)	0.1	0.1	1.0; 0.0 in floodway	1.0	--	--
7	Minimum crossing turnaround width (ft)[4]	Consult	Consult	--	--	30	--

No.	Design Consideration	USACE	CVFPB	Local Floodplain Ordinances (FEMA)	DWR Urban Areas	Irrigation Districts	California High-Speed Rail Authority
8	Detour distance requiring alternative access to other side of crossing (miles)[5]	Consult	Consult	--	--	2.0	--
9	Flood season construction restrictions	--	Yes	--	--	Yes	--

Notes:

1. The USACE originally indicated that 18 feet of clearance would be required above federal project levees. More recently, they have suggested that zero clearance (to eliminate all maintenance needs) or around 6 feet of clearance (to allow human access during inspection and maintenance) may be adequate in some situations (USACE 2011). Final requirements remain unresolved, and subject to negotiation between USACE, the CVFPB, the local levee maintenance agency and design consultants.
2. However, the USACE and CVFPB recently suggested that it may be preferable to armor the crossed section of levee or replace it with a concrete abutment and completely fill in behind the levee to form a solid, armored levee abutment. This is not settled, and remains subject to negotiation and final determination (USACE 2011).
3. CVFPB has recently indicated that it expects updated hydrology for design flows, rather than original, authorized flood-control project design flows.
4. See Figure 5-1.
5. If a detour exceeding a certain distance is required to access an irrigation channel on the other side of the HST Project barrier, a through-access, such as a tunnel, should be provided to allow a ditch rider to access the other side directly.
6. Effective 2015 in urban and urbanizing areas. Timing may depend on completion of studies by DWR and USACE.

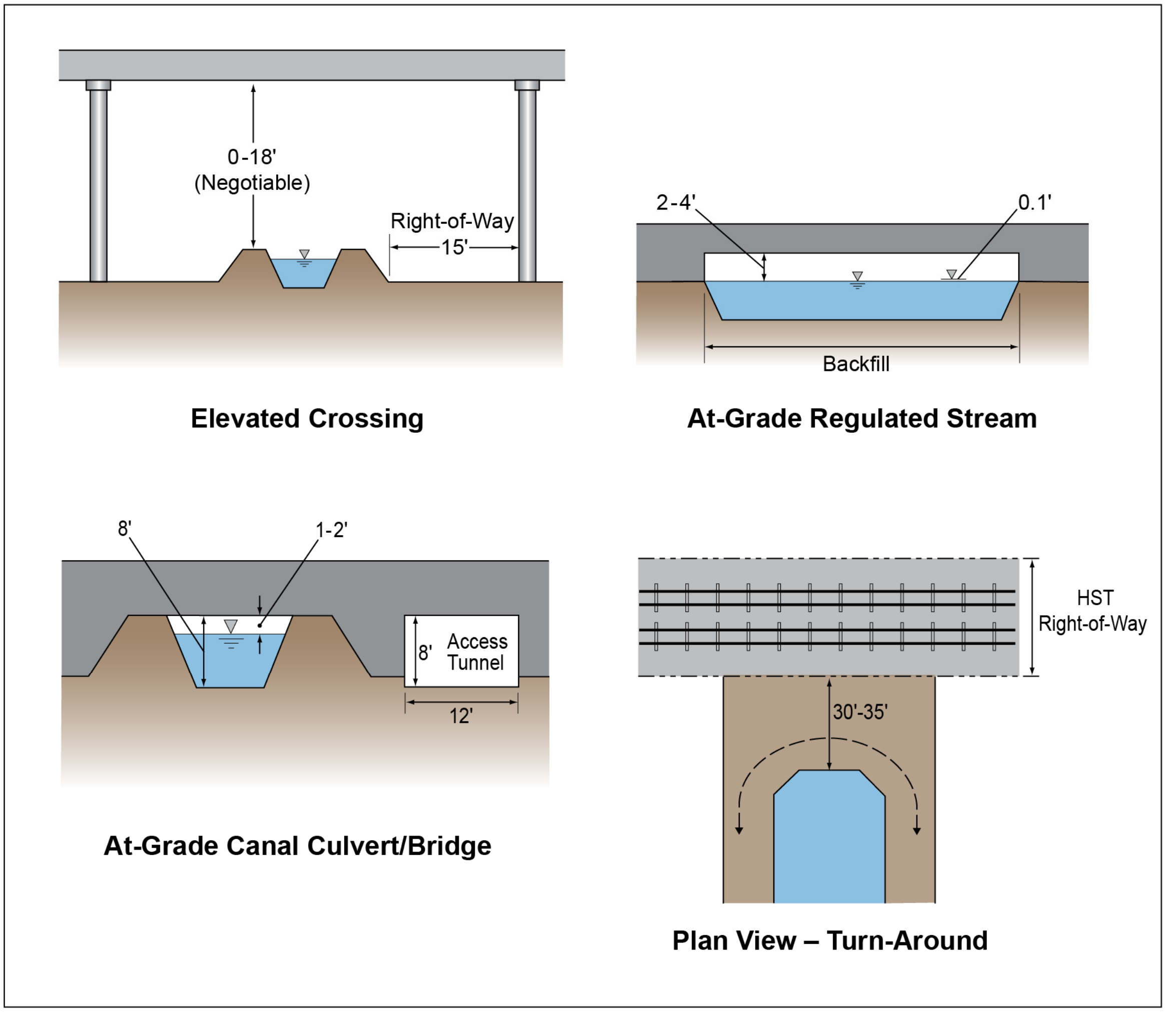

Figure 5-1
Representative Minimum Design Dimensions at Crossings
(Clearance Requirements at Elevated Crossings are Under Negotiation and May be Reduced.)

5.2 Design Flow

Applicable design flow rates for each crossing are presented in Appendix B, Hydrologic Design. If an adopted plan of flood control includes a state–federal flood control project, CVFPB, USACE and FEMA all have jurisdiction. The minimum required design flow depends on the type of crossing and the regulation under consideration. When more than one regulatory or project flow rate pertains, the largest design flow rate for the crossing should be used. The categories of flow rates that require consideration include the following:

- **State–federal flood control project authorized flow rate** – A project-specific flow rate and return period fixed by the authorizing legislation. Alternative or updated hydrology, such as by FEMA, would not alter the authorized design flow. See Sections 2.2.1 and 2.3.1.
- **FEMA 100-year base flood** – When available, the approved base flood flow rate is defined in the most recent FIS. On smaller or rural waterways, the base flood may not have been determined previously. See Section 2.2.4.

- **200-year base flood** – Beginning in 2015, DWR will require municipal floodplain ordinances for urban and urbanizing areas to manage to the 200-year base flood. See Section 2.3.3.
- **Canal design flows** – Many irrigation canals in the Central Valley convey both irrigation water and municipal stormwater, typically pumped from detention basins. In most cases, irrigation districts can refuse to accept stormwater once a canal has reached its capacity.
- **Best new hydrology** – Notwithstanding authorized project flow rates, recent communication by the CVFPB has suggested that original hydrology should be developed to establish a new design flow rate consistent with current and projected future hydrologic conditions (Taras 2011b).
- **Authority project minimum design flood** – The Authority has selected minimum flood return-period objectives for natural waterway crossings based on goals to protect the high-value HST facilities from flood-induced closures, delays or damage. Technical Memorandum 2.6.5 *Hydraulics and Hydrology Design Guidelines (TM 2.6.5*; Parsons Brinkerhoff 2011) summarizes current project design standards.

5.3 Flood Capacity

5.3.1 General

In general, natural drainages in Central California along the HST alignment flow in a westerly direction from the mountains and foothills in the east through the low-gradient Central Valley. Shallow, overland flooding tends to pond against canal berms, levees, and road embankments that cross down-gradient trajectories, unless there are adequate culverts or other means of cross-drainage flow passage. Based on FEMA floodplain maps, when steam channels exceed their banks under 100-year flow conditions, shallow flows on the order of 1 to 3 feet deep may spread out over areas that are thousands or tens of thousands of feet wide in portions of the Central Valley. Much of this flow is impounded behind existing embankments, such as Highway 99, with active conveyance under the embankments largely restricted to channels through bridges and culverts.

Adequate bridge openings, culverts, or siphons are important to allow for cross-drainage and prevent the HST and its new road embankments from blocking or diverting shallow flood flows. This is especially true where the HST project embankments form new barriers. Where the HST embankment is downstream of an existing embankment, care should be taken not to exacerbate existing flood problems. As a minimum, similarly sized and located bridge and culvert openings should be provided. However, when adjacent to undersized existing structures, current design standards must be met in the anticipation that existing structures may one day be retrofitted to improve overall conveyance. Where there are opportunities to relieve existing capacity limitations at the CHST footprint, they should be considered.

5.3.2 Maximum Rise and Minimum Freeboard

The minimum flood capacity at waterbody crossings must accommodate the design flow while maintaining the required freeboard and not exceeding the maximum rise criteria for the design-flow water surface elevation (WSE). Freeboard is intended to allow floating debris to pass without forming a blockage or debris dam, and to accommodate potential waves and hydrologic and hydraulic uncertainty. Specific hydraulic criteria depend on the crossing classification and the regulation under consideration. When more than one set of regulatory criteria applies, the most stringent criteria should be used for design. Flood capacity criteria for design include the following:

- **State–federal flood control projects** – The required freeboard between the design floodplain WSE and the lowest member of a bridge is normally 3 feet (CCR Title 23, Sect. 128.a.10.A), but can be reduced to 2 feet at trivial creeks where debris issues are minimal. Where the bridge crosses a levee, 4 feet of freeboard is normally required because (a) the normal 3 feet minimum freeboard to the top of a levee must be increased by 1 foot "within 100 feet of a bridge" unless there is an approved risk-based analysis (Section 120.a33.A), and (b) there must be "no depression in the crown of the levee" (Sect. 128.a.17).

- Where a levee is a state-federal flood control project levee, USACE should be consulted for required clearance above the levee itself. Preliminary guidance was 18 feet required clearance above the levee, but subsequent direction has indicated that zero clearance, 6 feet of clearance or other clearance metrics may be acceptable on a case-by-case basis.

- USACE requires that flow restrictions from the encroachment of piers, culverts, abutments or other project elements cause no more than a 0.1-foot rise in the project flood water-surface elevation at any location. Exceptions to these requirements would likely require a Section 408 permit (refer to Section 2.2.1).

- **Floodplain boundaries** – CVFPB, USACE, FEMA, DWR and other parties have mapped floodplain boundaries using best-available information, but in many cases mapped boundaries are approximate, without actual WSEs. If WSEs are not provided, hydraulic modeling is generally required to determine WSEs and final areas of inundation. Hydraulic modeling is required to assess incremental rise impacts resulting from the project.

- In the case of regulated streams without a designated floodway, CVFPB previously indicated that the project WSE is assumed to be at or below the top of the channel (no floodplain flow). Modeling would be required to demonstrate an elevation lower than the top of the streambank. More recent direction requested original hydrology and hydraulic models (Taras 2011a).

- **FEMA base flood incremental rise in WSE** – FEMA requires restricting floodplain encroachments such that they do not cause more than a 1-foot rise in the BFE over existing conditions at any location. In some cases, a local floodplain ordinance may be more restrictive than FEMA. For floodplains in the Procurement Package 1 area, local floodplain ordinances are consistent with the FEMA 1-foot-rise criteria.

- **FEMA floodway** – Zero rise criteria applies to floodways where they have been mapped.[1]

- **200-year floodplain** – At the time of this report, the 200-year floodplains mapped by DWR are preliminary and do not include design flow rates or WSEs.

- **Irrigation canals** – Irrigation districts along the alignment typically require between 1 and 2 feet of freeboard for bridges and box culverts. If a canal is also regulated for flood control by CVFPB, a minimum of 2 feet of freeboard may be required, under the assumption of limited debris. If the crossing design causes a rise in the canal WSE, a minimum of 1 foot of freeboard should be provided along the length of the canal. In addition, a minimum of 8 feet of vertical clearance is required from the bottom of the canal to allow for maintenance access for bridges. The section of canal that passes under the HST right-of-way should be concrete-lined to minimize maintenance requirements.

[1] No rise in base flood elevation is permitted if a development encroaches within the floodway itself. This is to prevent the accumulated effect of multiple projects from eventually resulting in more than a 1-foot rise in the base flood.

5.3.3 Other Requirements

- **Piped conveyance** – Irrigation conveyance should be piped under the HST right-of-way for smaller design flows (typically less than 100 cubic feet per second [cfs]) and in an open canal when flows are larger. The exact design flow cutoff for piped conveyance should be discussed with the appropriate irrigation district for each crossing. Based on preliminary discussions with the irrigation districts, they generally consider the minimum practical pipe size for inspection and maintenance to be 42 inches, but generally prefer 48 inches where a pipe would pass under the HST alignment and direct access for pipe replacement would be limited. Where direct access may be retained and irrigation ditches are relatively small (for example, where the permanent project footprint provides a new access road to a farmer's field and the new access road crosses a small irrigation ditch), culverts smaller than 42 inches may suffice. TM 2.6.5 indicates that the minimum pipe size allowable is 36 inches. Also, a siphon pipe beneath the track could potentially be downsized if velocities need to be increased to prevent excessive sediment deposition within the pipe.
- **Bridges (Title 23)** – Some sample regulations from Title 23 that pertain to bridges include the following:
  - Bridge piers and bents within the floodway must be constructed parallel to the direction of streamflow, and if widening a portion of an existing bridge, constructed in line with existing bents and piers.
  - Drainage from a bridge may not be discharged onto a levee section or streambank.
  - All construction facilities (such as temporary staging, cofferdams, and falsework) must be designed to prevent bank erosion during normal flows and to maintain maximum channel capacity during the flood season. If construction facilities remain in a floodway during flood season, plans must be submitted to CVFPB for approval prior to installation.
  - Bridge replacements and new bridges shall be built at an elevation so that there is no depression in the crown of the levee.
  - Locate abutments where they minimize impacts from channel constrictions.
  - Design for proper scour depth.
  - Access must be provided to maintain the bridge site free of accumulated debris.

5.4 Protection of Flood Control Structures

5.4.1 Culverts

Culvert inlets and outlets should be protected at crossings. Wing walls, riprap, or similar protection should be placed to protect the guideway embankment and outlet channel from possible erosion. The culvert design must meet hydraulic conveyance requirements, provide for collection of trash via a trash rack or adequate capacity to pass the anticipated debris, and have adequate room for inspection and maintenance when dry. When irrigation flows or runoff cannot be conveyed by a culvert pipe, open box culverts or a bridge are required.

5.4.2 Clearance and Offset from Levees and Embankments

When crossing an existing flood control structure, such as a levee, there are minimum requirements for vertical clearance, horizontal setback, and access. The specific requirements depend on whether the structure is part of a state–federal flood control project (i.e., a project levee) or part of a local or irrigation improvement, such as a canal embankment (i.e., a non-project levee). Appendix A, Water Crossings and Floodplains, identifies crossings over project and non-project levees. Clearance requirements for crossings at structures include the following:

- **State-federal flood control project structures** – If a bridge spans a state–federal flood control project structure, such as a levee, USACE originally stated that they require a minimum 18-foot clearance above the levee to provide access for emergency and maintenance equipment. After investigating further, and discussing challenges by the CVFPB, the USACE has determined that the 18-foot clearance requirement pertained to powerlines and that a lower clearance may be negotiated in some cases. Final requirements remain under discussion and subject to ongoing negotiations (USACE 2011). Piers or abutments must be set back a minimum of 10 feet from the outer levee toe and up to 20 feet in some cases (Title 23). A 15-foot setback is recommended in most cases so that clearance requirements are adequately satisfied. Recently, the USACE clarified that instead of a setback, the levee could be hardened or replaced to minimize maintenance concerns, and the area completely filled in behind the hardened levee section (USACE 2011). Exceptions to these requirements would likely require a Section 408 permit (refer to Section 2.2.1). The HST project design intends to minimize impacts on flood control projects and thereby allow permitting under Section 208.10 (i.e., CVFBP encroachment permit) without the requirement for a Section 408 permit.

- **Non-project levees** – CVFPB does not have a minimum clearance requirement above levees; however, local regulators, including the CVFPB, should be consulted for all levee crossings.

- **At-grade approach to non-project levees and canals** – As an alternative to spanning the levee with full clearance, which is typically practical only if the HST is already elevated, a spanned section of a non-project levee may be replaced with a low-maintenance, at-grade structure, such as a concrete box culvert or concrete bridge abutment. Integration of the existing levee embankment and engineered structural crossing should be properly designed to prevent levee failure or maintenance issues and satisfy requirements of the local levee maintenance agency. Use and design of an at-grade crossing of a state-federal flood control project levee should be negotiated with USACE to avoid triggering the need for a Section 408 permit.

5.5 Channel Stability and Scour Control

Note that site-specific geotechnical investigations, channel stability and detailed scour control evaluations have not been performed for conceptual design. Channel stability and scour and stability must be evaluated as part of final design. Additionally, erosion control may be required on the channel banks or levee slopes upstream and downstream from a proposed bridge to stabilize channel banks and bridge piers. A formal scour analysis should be carried out that considers the hydraulic conditions and channel characteristics at each crossing. Selected scour requirements defined in Title 23 include the following:

- Quarry stone, cobblestone, or their equivalent may be used for erosion control along rivers and streams if the materials meet the gradations specified in Table 5-2. Channel protection must include natural measures such as vegetation plantings.

Table 5-2
Required Gradations of Cobblestones and Quarry Stones for Erosion Control

Cobblestone		Quarry Stone	
Stone Size (inches)	**Percent Passing**	**Stone Size (inches)**	**Percent Passing**
15	100	15	100
10	55 to 95	10	80 to 95
8	35 to 65	8	45 to 80
6	10 to 35	6	15 to 45
3	1 to 5	3	0 to 15

- Bedding materials must be placed under the stone erosion control materials at locations where the underlying soils require stabilization because of streamflow velocity.
- Cobblestone protection must be placed on prepared slopes of 3 feet horizontal to 1 foot vertical (H:V) and may be used where streamflow velocities 10 feet from the bank do not exceed 8 feet per second.
- Quarry stone protection must be placed on prepared slopes steeper than 3H:1V and may be used where streamflow velocities 10 feet from the bank do not exceed 12 feet per second.
- Where streamflow velocities 10 feet from the bank exceed 12 feet per second, special cobble or quarry stone gradation is required. Flow-retarding structures, such as retards, wing dams, and rock groins may be permitted at these sites. CVFPB may permit the use of alternative bank protection materials. Possible alternatives include but are not limited to sacked concrete; broken concrete free of projecting steel, reinforced concrete, precast concrete jibbing, and stone-filled gabion baskets. Broken concrete used for levee revetment may be no larger than 16 inches in its maximum dimension.
- Asphalt or other petroleum-based products may not be used for fill or erosion control on a levee section or within a floodway.
- The minimum thickness of revetment is 18 inches perpendicular to the bank or levee slope below the usual water surface and 12 inches above the usual surface.

Stabilization of channel banks with stone alone may not be acceptable to CDFG and should be complimented with native riparian plantings or other natural stabilization alternatives that restore and maintain a more natural riparian corridor, where acceptable. However, Title 23 requires that "the area in and around a bridge site must be kept clear to maintain the design flow capacity. Trees, brush, sediment, and other debris must be kept cleared from the bridge site." In addition, where project levees abut bridges, large woody vegetation (e.g., trees) is generally prohibited under USACE guidelines because it could be a potential levee failure mechanism and a hindrance to levee inspection and maintenance.

5.6 Borrow and Excavation

Regulations restricting borrow and excavation activities defined in Title 23 include the following:

- Storage of borrow material is not permitted on a levee section, within 10 feet of a levee toe, or within 30 feet of the top bank of a river.
- Excavation is not permitted within 100 feet of a levee toe or property line within the floodway, within 50 feet of the toe of any spur levee (a levee that protrudes into the floodway to direct the flow of floodwater), or within a leveed floodway where there is active erosion unless an engineering study demonstrates that the borrow will not exacerbate the erosion.
- The side slopes of a borrow area may not exceed 3H:1V.
- If connected to a low-water channel, a borrow area must transition smoothly at the upstream and downstream ends and drain smoothly toward the channel.
- The bottom elevation of any berm excavation may not be lower than the adjacent channel bottom without adequate setback from the channel (typically 500 feet).
- Any proposed borrow operation within 1 mile of a state highway bridge must be approved by Caltrans.
- A geotechnical investigation is required before initiating any borrow activity within a leveed floodway. The investigation must determine if the proposed borrow activity would increase seepage beneath levees, or expose soils susceptible to erosion.
- Any excavation within the levee section or near bridge supports within the floodway must be backfilled in 4- to 6-inch layers with approved material. Levee sections must be compacted to a relative compaction of not less than 90% in accordance with American Society of Testing and Materials (ASTM) D1557-91, dated 1991, and above optimum moisture content. Compaction within the floodway must be to the density of the adjacent undisturbed material. Compaction tests by a certified soils laboratory may be required to verify compaction.
- Waivers may be granted for borrow and excavation activities if supported by detailed studies that justify the waiver.

5.7 Pipelines, Conduits, and Utility Lines

Title 23 defines regulations governing linear conduit features, especially where they penetrate a project levee, as described in the following sections.

5.7.1 General

- Appurtenant structures are generally not permitted within 10 feet of the levee toes to prevent interference with levee maintenance or flood fighting activities.
- Overhead electrical and communication lines must have a minimum vertical clearance above the levee crown and access ramps of 21 feet for lines carrying 750 volts or less, and 25 feet for lines carrying higher voltage.
- Low-voltage electrical or communication lines of 24 volts or less may be installed parallel to a levee and within 10 feet of the levee toe when it is demonstrated to be necessary and to not interfere with the integrity of levee, levee maintenance, inspection, or flood fighting activities.

5.7.2 Within the Floodway

- For utilities a minimum cover of 5 feet is required beneath low-water channels and a minimum of 2 feet of cover is required in the remaining area of the floodway. A thicker cover may be required, depending on channel hydraulics.
- Open-trench backfill using suitable material compacted to the density of adjacent undisturbed material is required. Compaction tests by a certified soils laboratory may be required.
- All debris that accumulates around utility poles and guy wires within the floodway must be completely removed after the flood season and immediately after major accumulations.

5.7.3 Through a Levee

- Pipelines, conduits, and utility lines must be installed through a levee as nearly at a right angle to the levee centerline as practical, and must have a location marker on the levee slope adjacent to either shoulder. Buried pipelines, conduits, and utility lines that do not surface near the levee toes must have location markers near both levee toes.
- The minimum cover for pipelines, conduits, and utility lines installed through the levee crown is 24 inches, or a concrete or other engineered cover is required. The minimum cover within the levee slope is 12 inches.
- When practical, pipelines, conduits, and utility lines installed within a levee section must be separated from parallel pipelines, conduits, and utility lines by a minimum of 12 inches, or the diameter of the largest pipeline, conduit, or utility line, whichever is larger, to a maximum of 36 inches.
- Electrical and communication lines installed through a levee or within 10 feet of a levee toe must be encased in Schedule 40 polyvinylchloride (PVC) conduit or equivalent. Low-voltage lines (24 volts or less) and fiber optic cables may be allowed without conduit if properly labeled.
- A standard reinforced concrete U-wall for levee erosion protection is required at the outlet end of a pipeline or conduit discharging within 10 feet of a levee toe (Title 23 provides design figures).
- Excavations within the levee or within 10 feet of levee toes for the installation of a pipeline, conduit, or utility line must be backfilled in 4- to 6-inch layers with approved material and compacted to a relative compaction of not less than 90% in accordance with ASTM D1557-91, dated 1991, and above optimum moisture content; or 97% in accordance with ASTM D698-91, dated 1991. Compaction tests by a certified soils laboratory will be required to verify compaction of backfill within a levee.
- Boring a pipeline or conduit through a levee is permitted if certain conditions are met.
- Pipelines open to the waterway must be a minimum of 30 inches in diameter, and must have a readily accessible positive closure device installed on the waterward side.
- Seepage along pipelines, conduits, and utility lines must be prevented by encasement in reinforced concrete cast against firm undisturbed earth, or the conduit must have reinforced concrete battered walls at an inclination of 1H:4V or flatter.

5.7.4 Trenching

- The side slopes of trenches excavated for the installation of pipelines, conduit, or utility lines may be no steeper than 1H:1V; except vertical side slopes may be allowed for shallow (12-inch) installations above the floodplain and that portion of the trench above the design freeboard.
- The bottom width must be 2 feet wider than the diameter of the pipeline or conduit, or 2 times the pipe diameter, whichever is greater.
- When practical, pipelines, conduits, and utility lines must have a minimum vertical spacing of 6 inches when crossing other pipelines, conduits, or utility lines.

5.7.5 Jacking

Pipelines, conduits, and utility lines may be installed under a levee or stream channel by tunneling, jacking, or boring, if the following conditions are met:

- The pipeline, conduit, or utility line is at least 30 feet under the levee.
- The installation is more than 50 feet below the levee and the entire floodway and streambed; the CVFPB may waive the requirement for a permit if a letter of intent is filed with the CVFPB prior to commencement of the project.
- The portal and outlet of a tunnel, jacking, or boring must be a minimum of 10 feet beyond the projected levee slope without an approved stability and seepage analysis.
- Installation may occur during the flood season and when the WSE in the floodway is expected to be above the elevation of the landside levee toe if adequate containment cells are constructed at the portal and outlet.

5.7.6 Materials

The following pipe materials are allowed within a levee section when designed to resist all anticipated loading conditions and properly installed:

- Galvanized iron pipe is allowed if all joints are threaded. Galvanized iron pipe joints must be protected from corrosion by using PVC or polyethylene tape wrapped to a thickness of 30 mil or equivalent.
- Schedule 80 PVC pipe may be used if it is entirely buried, all joints are threaded, and the components have been continually protected from ultraviolet radiation damage or they are newly manufactured.
- Schedule 40 PVC or better may be used as a conduit for power or communication cables.
- High-density polyethylene (HDPE) pipe may be used for pipeline or conduit installations provided certain conditions are met.
- Cast-in-place reinforced concrete pipes and box culverts may be used above and below the design flood WSE if the concrete is at least 6 inches thick.
- Precast reinforced concrete pipes and box culverts and concrete cylinder pipes may be used above and below the design flood WSE if certain conditions are met.

- Steel pipe may be used for all types of pipeline or conduit installations through a levee above the design flood WSE provided that certain conditions are met. Steel pipe meeting the following criteria may be used without submittal of design calculations to the CVFPB:
  - Ten-gauge steel pipe that is 12 inches in diameter or less.
  - Seven-gauge steel pipe that is between 12 to 30-inch-diameter.
  - Three-gauge steel pipe that is between 30 to 48 inches in diameter.

The following materials are not allowed for pipelines or conduits that carry fluids within a levee or within 10 feet of levee toes: aluminum pipe, cast iron pipe, pipe with flanges, flexible couplings, or other mechanical couplings or pre-stressed concrete.

5.8 Access

In general, natural waterways and irrigation channels are used for both irrigation and flood conveyance. Access is required at every crossing to allow for maintenance, flood patrols, and convenient operations. The following sections discuss access requirements that should be considered in the design.

5.8.1 Levee and Channel Access

Vehicle access from the levee crown to the floodway and/or the landside levee toe beneath the bridge may be required. Ramps may slope upstream as necessary to provide the access. Title 23 provides guidelines for patrol roads and access ramps. Patrol roads provide vehicular access along levee crowns and flood channels for inspection, maintenance and flood fighting. Patrol roads must meet the following criteria:

- Patrol roads must be surfaced with a minimum of 4 inches of compacted, Class 2 aggregate base (Caltrans Spec. 26-I.02A, July 1992), or equivalent.
- Patrol road surface material must be compacted to a relative compaction of not less than 90% in accordance with ASTM 01557-91, dated 1991, with moisture content sufficient to achieve the required compaction.
- Compaction tests by a certified soils laboratory may be required to verify compaction.
- Ramps provide access to the levee crown from adjacent property and roads, either head-on or via a side approach.
- Access ramps must be constructed of approved imported material.
- Surfacing for access ramps must be the same as for patrol roads.
- Excavations made in a levee section to key the ramp to the levee must be backfilled in 4- to 6-inch layers with approved material and compacted to a relative compaction of not less than 90% in accordance with ASTM 01557-91, and above optimum moisture content.
- Compaction tests by a certified soils laboratory may be required to verify compaction.
- All access ramps must direct surface drainage away from the levee section. Title 23 shows typical plans for each type of approach ramp, with restrictions and requirements.

5.8.2 Bi-directional Access

In general, access is required to both sides of the HST right-of-way and to both banks of waterways. Where the HST track abuts an adjacent linear right-of-way, such as the right-of-way for the UPRR and BNSF railways and SR 99, access need only be provided to the HST right-of-way without existing access.

5.8.3 Through Access

Where there is access on both sides of the HST right-of-way, USACE and the irrigation districts prefer access through the guideway embankment via a box culvert or similar tunnel. Preliminary minimum dimensions for the box culvert are 8 feet high and 12 feet wide to accommodate a standard large pickup truck used by ditch riders. The box culvert may be located at or beyond the landside levee toe if access ramps and right-of-way are provided. Through access may not be practical in all cases, but it is considered especially important where alternative access requires a detour of 2 miles or more.

5.8.4 Turn-Around Access

In general, embankment crests provide insufficient room to turn around. Where there are raised embankments, narrow rights-of-way, or no through access on both sides of the waterway, the design should include cul-de-sacs on both sides of the waterbody crossing that extend approximately 30 to 35 feet beyond the HST right-of-way to allow the largest irrigation equipment to cross the waterway and return on the other side. Unless another waterway crossing is nearby and a properly sized cul-de-sac is provided for a dead-end turnaround, access across the waterway is required.

5.8.5 Maintenance Access

Figure 5-1 illustrates access height and width requirements for maintenance access. Access points must be able to accommodate maintenance vehicles ranging from large backhoes that maintain a project levee during a flood to small bulldozers that clear debris from canals during the off-season.

5.9 Seasonal Construction Restrictions

5.9.1 Natural Channels

CVFPB restricts construction within the floodplain of regulated streams during the designated flood season.

The following list provides examples of restricted activities listed in Title 23:

- Excavation is not allowed within the floodplain or channel during the designated flood season without a waiver.
- Stockpiles of unsecured materials or equipment are not allowed within the floodway during the designated flood season.
- Pipelines, conduits, utility lines, utility poles, and appurtenant structures may not be installed within the levee section, within 10 feet of levee toes, or within the floodway during the flood season unless authorized by the general manager based on reservoir levels, stream levels, and forecasted weather conditions on a case-by-case basis.

Irrigation districts prohibit in-channel construction during the irrigation season, unless provision is made to maintain irrigation deliveries. The irrigation season varies with the weather and available storage, but generally begins in mid spring (April) and extends through mid fall (October).

Together, the flood season and the irrigation season span 12 months, and exceptions would be required. CVFPB accepts applications for exemptions to flood season construction restrictions. Irrigation districts determine exceptions to irrigation-related construction.

5.9.2 Irrigation Channels

Discussions should take place with the appropriate irrigation district to determine the acceptable construction window for constructing irrigation canal crossings. In some cases, a canal may be in operation year round, with the following functions: primarily irrigation flows in the spring, summer, and fall; potential conveyance to groundwater recharge facilities or other storage facilities when irrigation demands are low; and flood conveyance during the wet season. FID has indicated that the likely construction window for Herndon Canal is September and October, but this will depend on the irrigation season in a given year and on other canal operations. FID has indicated that the construction window will vary from year to year based on the length of irrigation season, flood routings, recharge deliveries, maintenance projects and projects funded by others. FID's typical irrigation season begins on March 1, with FID opening the head gates to fill the canals/pipelines approximately 8 days prior (approximately February 21). An average irrigation season lasts 6 months; therefore the season will typically end on August 31. In very wet years, such as 2011, the irrigation season may go through mid-November.

It should be noted that all construction must occur outside FID's irrigation season. A typical construction window would be September 1 through Feb 22. The canals typically take approximately 1-2 weeks to drain.

It should also be noted that many of the impacted canals are also utilized to convey stormwater. The canals serve as major arteries of the FMFCD and Army Corps of Engineers flood routing system. The stormwater is a combination of water pumped from urban stormwater systems and water from foothill flood control projects within and under the jurisdiction of FMFCD. Once the floodwater enters FID's canal system, FID routes the water through various canals, but the majority through the Herndon and Dry Creek Canal systems, to various basins located on the west side of FID.

Depending on the canal system, construction schedule, water season, and storm season, a bypass may be needed. If a bypass is not constructed, all water will be required to pass through the project site. FID will determine the minimum flow rate if a bypass is required. The Engineer and/or Contractor will be responsible for designing the bypass system. The bypass system shall include facilities as necessary to convey waters downstream and away from the project such as a channel, pipeline, or bypass pumps (with redundancy). Facilities shall be the responsibility of the Contractor to install and maintain at all times. It is recommended that FID be consulted regularly as the design continues.

5.10 Other Studies

To issue encroachment permits, Section 408 permits, or building permits, agencies may require additional information, such as geotechnical explorations, soil testing, hydraulic or sediment transport studies, scour analysis, biological surveys, environmental surveys, and other analyses. The relevant agency(s) should be contacted as early as possible to confirm the specific information required for each crossing.

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Appendix A
Water Crossings and Floodplains

A1 Crossing Locations

The limits and alignment of Procurement Package 1 (committed to build) are shown on Figure A-1. Table A-1 lists individual crossings by their ID number and name, as well as a high-level summary of conceptual designs and map references. There are 14 water crossings along the Procurement Package 1 alignment. The crossing locations are shown on Figure A-2, which include an alphanumeric map grid system that coincides with the crossing locations in the last column of Table A-1.

Table A-1
Inventory of Waterbody Crossings

Crossing ID	Waterbody Name	Existing Water-body Type and Installed Crossing	30% Design Vertical Alignment	Water-body Length Parallel to Track (feet)	Owner	30% Design	Figures A-2 Map and Grid Location
408D	Veterans Boulevard	Major storm flow path, as identified by FMFCD	At-grade	N/A		TBD	A-1
410C-HrCa	Herndon Canal	Canal crossed by 5 box culverts (7' w x 5.5' h each bay)	At-grade	N/A	FID	Bridge: 2-span HST bridge per FID standard to replace existing; 1-span bridge at new Golden State Blvd crossing.	A-2
412D	Cornelia Avenue	Major storm flow path, as identified by FMFCD	At-grade	N/A		TBD	B-2
415P-LiCa	Lisenby Canal No. 45	Pipe Sequence: 36” unknown type (1936), 24” Rubber-Gasket Reinforced Concrete Pipe (RGRCP) (1981), 2.5’x3’ concrete box	At-Grade	N/A	FID	Pipe: 24” RGRCP[size matches modern upstream and at-site installations in 1981, 1996 and 2010; downsized from 36” in 1908 and 1936 for consistent diameter]	B-2
417D	Brawley Avenue	Major storm flow path, as identified by FMFCD	At-grade	N/A		TBD	B-2
418D	Ashland Avenue	Major storm flow path, as identified by FMFCD	At-grade	N/A		TBD	B-3

Crossing ID	Waterbody Name	Existing Water-body Type and Installed Crossing	30% Design Vertical Alignment	Water-body Length Parallel to Track (feet)	Owner	30% Design	Figures A-2 Map and Grid Location
420P-ViCa-B	Victoria Canal No. 42	42" RGRCP (1957) that splits near the west edge of the ROW into Victoria Colony No. 43 [36" RGRCP (1957 & 2004)] and Tracy No. 44 [30" RGRCP (1957) and 30" NRCP (1991)]	At-Grade	1220	FID	Pipe: 42" RGRCP with 36"/30" RGRCP split to connect to existing downstream pipes. Box control structure outside the ROW for FID access.	C-3
832C-VCCa-A	Victoria Colony Canal No. 43	Canal after pipe daylights.	At-Grade	1140	FID	No change to existing waterbody; project work at this location consists of road repaving.	C-3
421P-CWBC-B	Cole West Br. Canal No. 40	Pipe – Abandoned by FID	At-Grade	850	FID	None – Existing pipes are abandoned and do not need replacement.	C-3
834P-CWBC-A	Cole West Br. Canal No. 40	Pipe – Abandoned by FID	At-Grade	80	FID	None – Existing pipes are abandoned and do not need replacement.	C-4
423D	McKinley Avenue	Major storm flow path, as identified by FMFCD	At-grade	N/A	City of Fresno	Culvert	D-4
422P-CSBC	Cole South Branch No. 40	24" NRCP-M Pipe	At-Grade	60	FID	24" RGRCP Pipe	D-4
451C-DCCa	Dry Creek Canal No. 75	Open Channel Canal	Below Grade	60	FID	Box Culvert Viaduct over Rail ROW and additional improvements at North Thorne Ave	D-5
445D	Divisadero Street	Major storm flow path, as identified by FMFCD	At-grade	N/A	City of Fresno	Channel above the below grade HST alignment	E-5

A2 Owners

A2.1 FID

FID is located in the geographic center of Fresno County and its boundary extends from the San Joaquin River to the north, City of Easton to the south, the Kings River and Friant-Kern Canal to the east and just past the City of Kerman to the west. Water is delivered to agriculture lands as well as the metropolitan areas of Fresno and Clovis. FID diverts an average of 500,000 acre-feet or surface water annually.

The HSRA should recognize that many FID facilities will be directly impacted by the project and will most likely increase FID's Operation and Maintenance costs. To help offset or avoid these additional costs, the Authority will need to make the necessary improvements to FID's infrastructure. FID encourages the Authority to consider this when designing all improvements. Although most of the road crossings will be relocated either under or over the HST, there will be several road crossings that will be eliminated (e.g. Malaga Avenue, intersection of California, Cherry and Railroad avenues, etc.) and this will impact FID operations. These impacts may include but are not limited to: accessibility to system and facilities, increased travel times, increased vehicle mileage, increased operating costs for FID employees to complete necessary tasks due to inability to travel directly and efficiently between work sites, and increased number of employees being required to complete necessary tasks, etc.

A2.2 Private Owners

There are several privately owned facilities that may be impacted by the Project. FID does not own, operate, or maintain these facilities; however they are used to convey surface water from FID to private users. FID will provide a list of water users upon request.

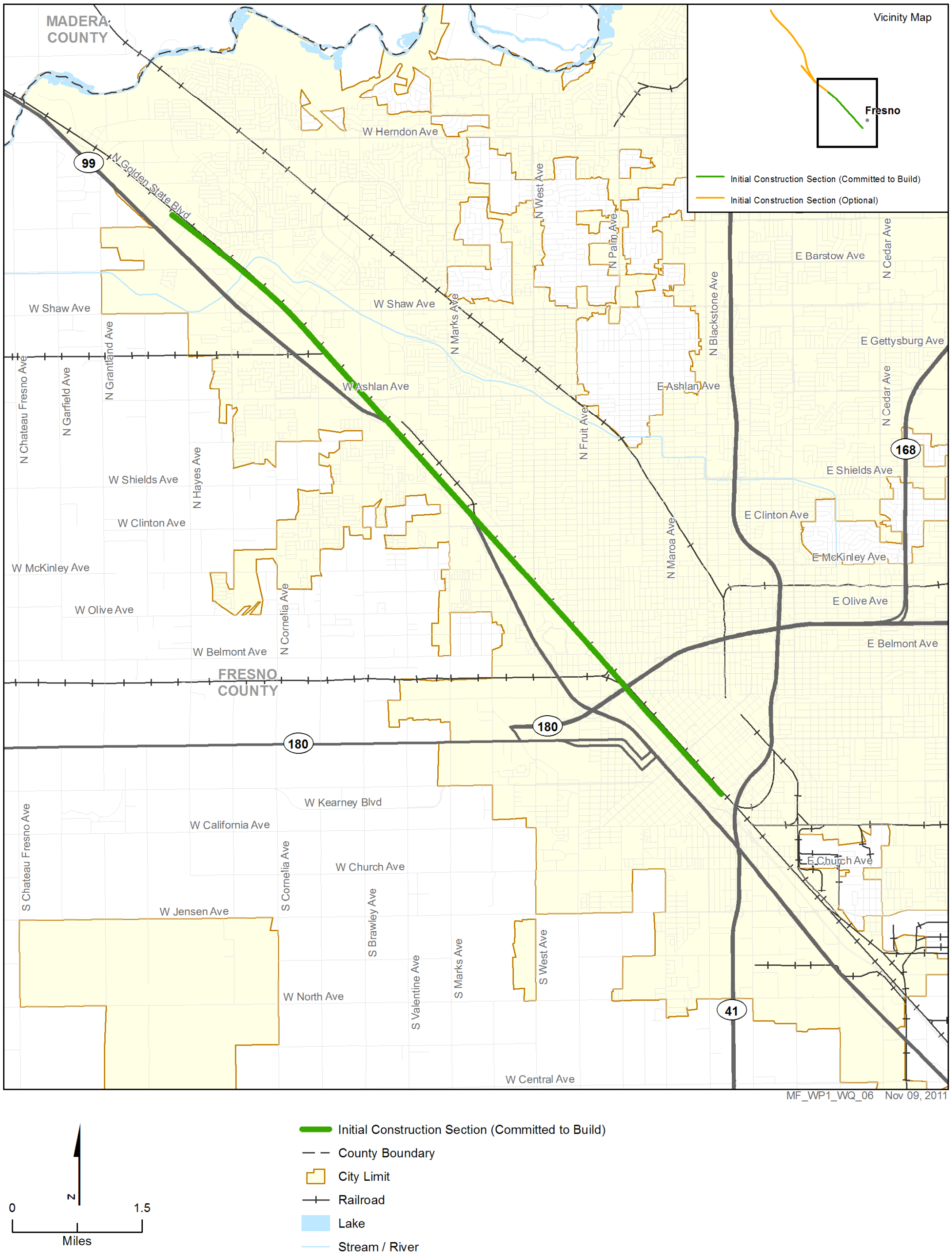


Figure A-1
Procurement Package 1 Limits and Alignment

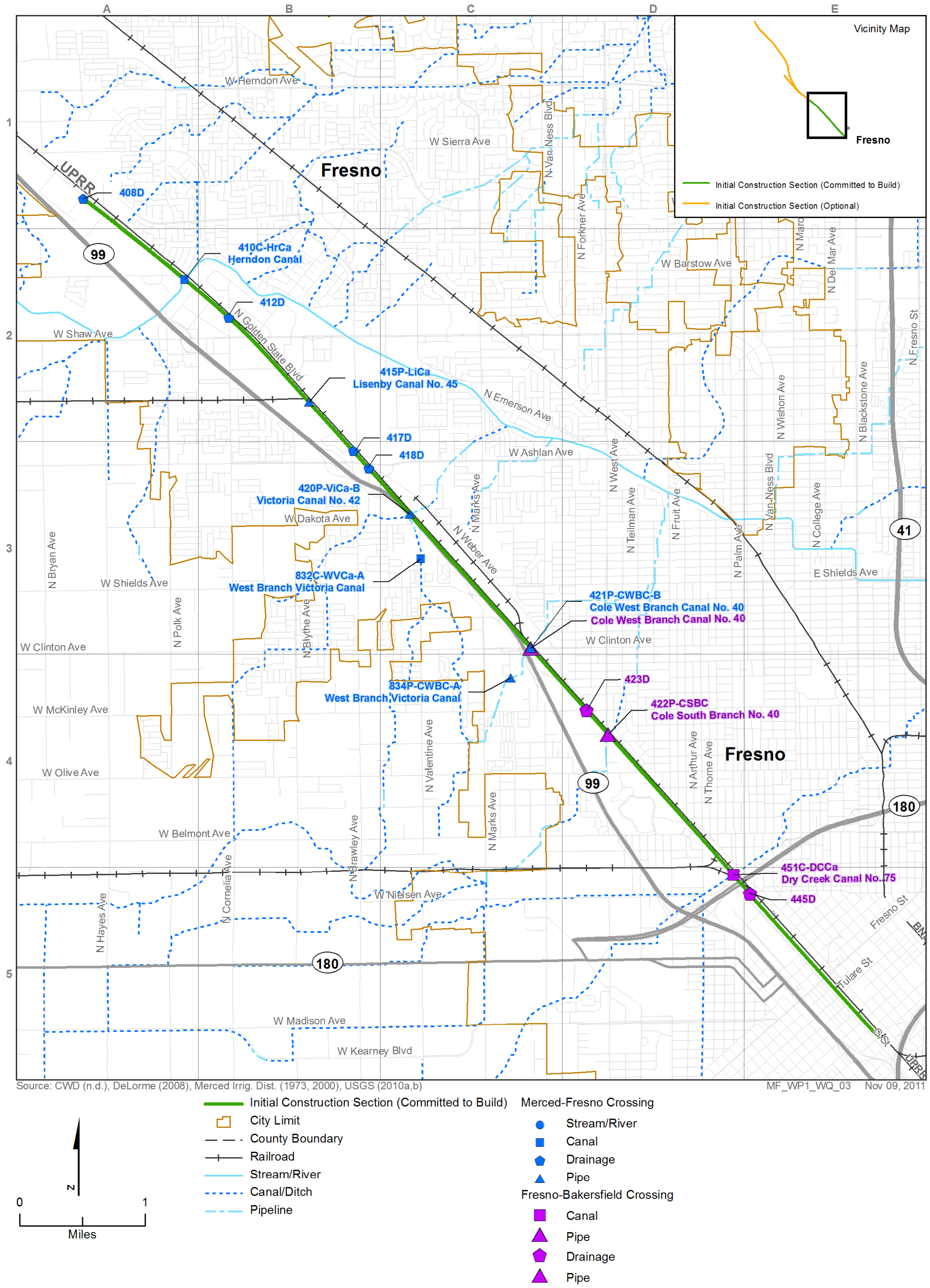


Figure A-2
Waterbody Crossings

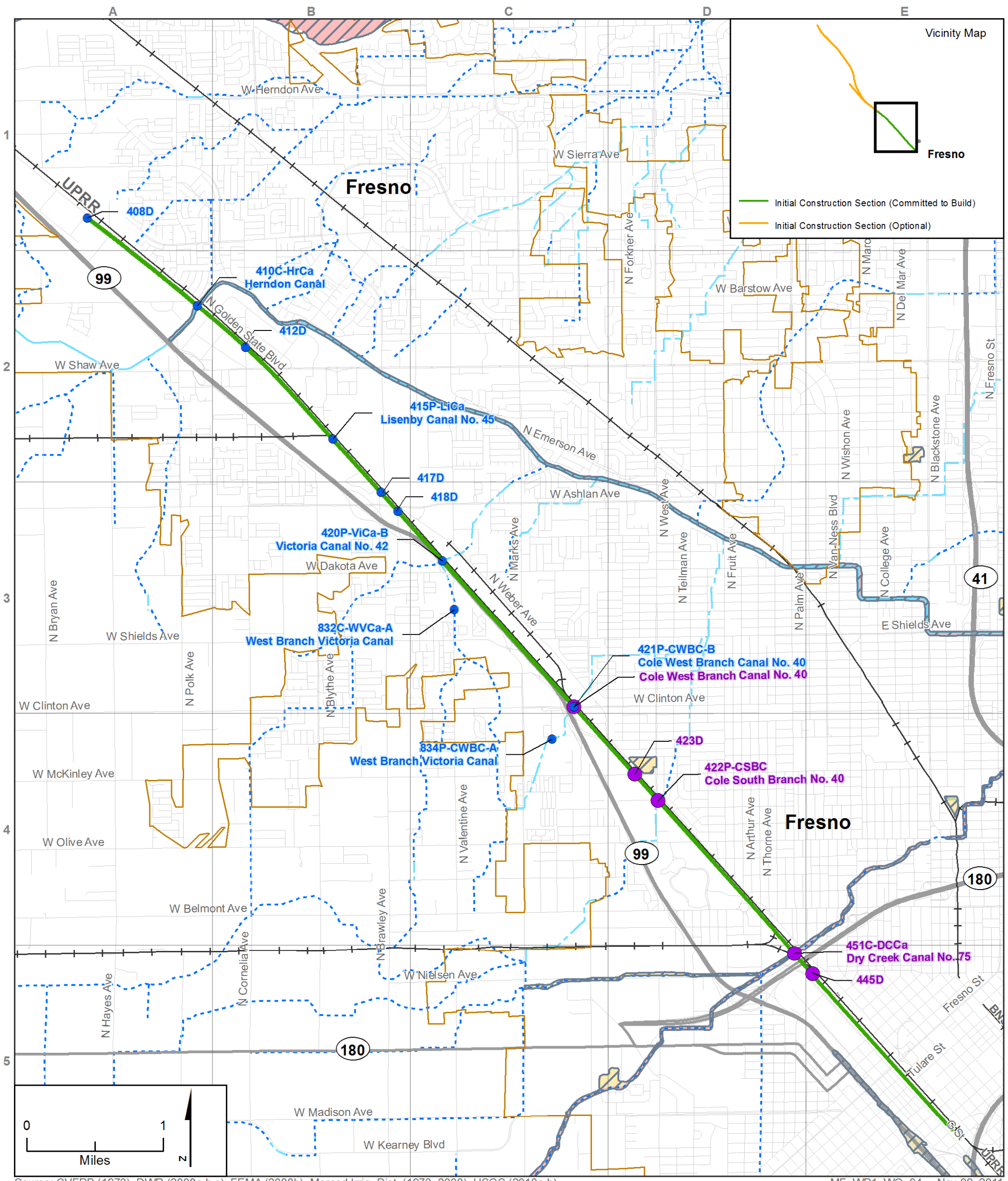
A3 Floodplains Crossed

Table A-2 presents approximate floodplain widths crossed by the project alignment. Figure A-3 shows the floodplains in the project area and that would be crossed by the project. The project would cross the Herndon Canal, which occasionally conveys flood flows. Other flood zones crossed by the project include Dry Creek Canal.

Table A-2
Floodplain Widths

Crossing ID	Crossing Name	Floodplain Widths Crossed (ft)			
		FEMA 100-year Floodplain	FEMA Floodway	CVFPB Designated Floodway	DWR 200-Year Floodplain[1]
410C-HrCa	Herndon Canal	110	N/A	N/A	110
451C-DCCa	Dry Creek Canal	70	N/A	N/A	TBD

[1] Original hydrology may be required to determine the 200-year floodplain widths.



Source: CVFPB (1973), DWR (2008a,b,c), FEMA (2008b), Merced Irrig. Dist. (1973, 2000), USGS (2010a,b)

MF_WP1_WQ_04 Nov 09, 2011

- Initial Construction Section (Committed to Build)
- City Limit
- County Boundary
- Railroad
- Stream/River
- Canal/Ditch
- Pipeline
- Merced-Fresno Crossing
- Fresno-Bakersfield Crossing

- A — Areas with a 1% annual chance of flooding. No depths or base flood elevations have been determined for this zone.
- AE — Areas with a 1% annual chance of flooding. Base flood elevations have been determined for this zone.
- AH — Areas with a 1% annual chance of shallow flooding, usually in the form of a pond, with an average depth ranging from 1 to 3 feet. Base flood elevations derived from detailed analyses are shown by FEMA for selected intervals within this zone.
- AO — River or stream flood hazard areas and areas with a 1% or greater chance of shallow flooding each year, usually in the form of sheet flow, with an average depth ranging from 1 to 3 feet. Average flood depths derived from detailed analyses are shown by FEMA within this zone.

- California DWR 200-Year Floodplain; preliminary and subject to change
- Central Valley Flood Protection Board Designated Floodway
- State-Federal Project Levee
- Nonproject Levee

Figure A-3
Floodplains, Floodways, and Levees

A4 Anticipated Floodplain Permits Needed

The floodplain permits that are likely to be required at each crossing location are identified in Table A-3.

Table A-3
Anticipated Permits Needed

Crossing ID	Crossing Name	Crossing Type	Section 408 Permit	Encroachment Permit						FEMA NFIP Local Floodplain Development Permit	Caltrans Design Approval
				Section 408 Ruling	USACE Section 208.10 Compliance (Federal Project)	CVFPB Floodway	CVFPB Title 23 Table 8.1	Tributary/Designated Flood	Canal with Designated Flood Capacity		
410C-HrCa	Herndon Canal	Canal							X	X	
415P-LiCa	Lisenby Canal No. 45	Pipe									
420P-ViCa-B	Victoria Canal No. 42	Pipe									
832C-VCCa-A	Victoria Colony No. 43	Canal									
421P-CWBC-B	Cole West Br. Canal No. 40	Pipe									
834P-CWBC-A	Cole West Br. Canal No. 40	Pipe									
422P-CSBC	Cole South Branch No. 40	Pipe									
451C-DCCa	Dry Creek Canal No. 75	Canal								X	

A5 Crossing Descriptions

Figure A-2 shows crossing locations. Hydrologic features of each crossing are described in Appendix B, Table B-1. Hydraulic features of each crossing are described in Appendix C, Table C-1.

A6 Overland Flow Locations

FMFCD requires that the HST alignment be designed to maintain the passage of the major storm surface flow patterns. As the HST alignment is located near the Union Pacific Railroad (UPRR) and generally above its rails, run-on from up-gradient areas onto the HST project length in Procurement Package 1 generally does not occur. FMFCD has committed to work to assist HST engineering consultants to identify the appropriate improvements at locations that may be identified as the Project design progresses.

The HST proposes to close several existing street crossings. As such, surface drainage patterns must be carefully reviewed and drainage patterns maintained with a series of cross drains or other approved conveyance systems, including provisions for any major storm flows across the HST. The change in street improvements in the vicinity of the HST must be similarly mitigated with respect to drainage impacts. To assist HST, FMFCD has identified the following roadways where major storm surface flows must cross the HST alignment: Veterans Boulevard, Cornelia Avenue, Brawley Avenue, Ashlan Avenue, McKinley Avenue and Divisadero Street. These drainage water crossings are shown as crossing IDs 408D, 412D, 417D, 418D, 423D, and 445D in Figure A-2 and in Table A-1. Proposed upgrades to the drainage systems serving these streets can be found in the 30% design drawings for Procurement Package 1.

Appendix B
Hydrologic Design

B1 Overview

When possible, existing hydrologic design flows were used for the HST project. Sources of existing information include:

- Fresno Irrigation District
- Fresno Municipal Flood Control District
- FEMA Flood Insurance Study (FIS)

B2 Original Hydrology

Design high flows were provided by FID. Therefore no original hydrology was developed for Procurement Package 1.

B3 Design Flows

Table B-1 summarizes preliminary design flows. These should be reviewed with the appropriate permitting agency and confirmed or revised as necessary during subsequent design.

Table B-1
Inventory of Hydrologic Information

				USACE Levee O&M Manuals			CVFPB-Designated Floodway Program		FEMA FIS				DWR		Local		Authorized Design Flow	
Crossing ID	**Waterbody Name**	**Regulatory Status**	**Some Required Hydraulic Permits**	**Design Capacity (cfs)**	**Flood Control Project**	**Year of Author-ization**	**Design Flow ***** (cfs)**	**Year Adopted**	**100-year Peak Flow Rate (cfs)**	**500-year Peak Flow Rate (cfs)**	**Source**	**100-year Flood Hazard Zone**	**200-year Peak Flow Rate (cfs)**	**Study Year**	**FID Peak Irrigation Flow (cfs)**	**FID/ FMFCD Peak Flood Flow (cfs)**	**Design Frequency (%)**	**Design Flow (cfs)**
410C-HrCa	Herndon Canal	FID Canal with FMFCD agreement for flood conveyance	Encroachment per CVFPB expanded jurisdiction	N/A	None	N/A	N/A	N/A	550	Does not exist	Fresno County FIS (2009)	AE	550 per FID	1993 for FMFCD	550	600	100-year	600
415P-LiCa	Lisenby Canal No. 45	FID - Pipe	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	9	N/A	9
420P-ViCa-B	Victoria Canal No. 42	FID - Pipe	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	30	6	N/A	30
832C-VCCa-A	Victoria Colony Canal No. 43	None – No Hydraulic Change	N/A	N/A	N/A	N/A	N/A	N/A	No	No	None	None	N/A	N/A	18	6	N/A	18
421P-CWBC-B	Cole West Br. Canal No. 40	FID – Abandoned Pipe	Abandoned															
834P-CWBC-A	Cole West Br. Canal No. 40	FID – Abandoned Pipe	Abandoned															
422P-CSBC	Cole South Branch No. 40	FID – Pipe	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	0	N/A	5
451C-DCCa	Dry Creek Canal No. 75	FID - Open Channel Canal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	450	425/ 500	N/A	500

Appendix C
Hydraulic Design

C1 Overview

Hydraulic modeling using the USACE hydraulic model HEC-RAS was performed for open channel crossings to determine the design flood elevation and potential incremental rise caused by the design. Hydraulic modeling was performed for the Herndon Canal and Dry Creek Canal crossings (410C-HrCa and 451C-DCCa). When possible, hydraulic models were calibrated to known flood elevations; otherwise, models were based on reasonable, conservative input parameters. The basis of input parameters is described in the sections below. The preliminary modeling analysis for both Herndon Canal and Dry Creek Canal show that there would be no net rise in water surface elevation after the project (at the design flow) when compared to the existing water surface elevation. An inventory of hydraulic information for these crossings is provided in Table C-1.

Where irrigation and flood flows are currently contained within pipes at the crossing locations hydraulic analysis was not performed (415P-LiCa, 420P-ViCa-B, and 422P-CSBC). Replacement pipe sizes for these locations were specified by FID based on existing pipe sizes and/or FID's internal master plan requirements. Because the pipes at crossings 421P-CWBC-B and 834P-CWBC-A are abandoned and because changes are not proposed to crossing 832C-VCCa-A, hydraulic analyses are not necessary. An inventory of hydraulic information for these crossings is provided in Table C-1.

The capacity at major storm surface flow conveyance crossings, discussed in Appendix section A6, has not been designed, and will need to be provided (408D, 412D, 417D, 418D, 423D, and 445D). FMFCD has committed to work to assist HST engineering consultants to identify the appropriate improvements at locations that may be identified as the Project design progresses.

Table C-1
Inventory of Hydraulic Information

Crossing ID	Waterbody Name	Available Survey Information	Readily Available Hydraulic Information	Historical Floods	High Water Mark Elevation	Available FEMA Flood Depths	Additional Hydraulic Analysis Needs
410C-HrCa	Herndon Canal	cross-sections and aerial	FIS Water surface profile (FEMA 2009a)	Peak flow of 550 cfs in past 20 years; 444 cfs in past 6 years	Surveyed (see Table C-2)	100-yr profile = 302.6 feet NAVD 88 from Fresno FIS panel 27 (FEMA 2009a)	Modeling – HEC-RAS Complete
415P-LiCa	Lisenby Canal No. 45	N/A- existing pipe. 30% replacement design specified in Table A-1					No
420P-ViCa-B	Victoria Canal No. 42	N/A- existing pipe. 30% replacement design specified in Table A-1					No
832C-VCCa-A	Victoria Colony No. 43	N/A- No change to existing waterbody					
421P-CWBC-B	Cole West Br. Canal No. 40	N/A- existing pipe is abandoned					
834P-CWBC-A	Cole West Br. Canal No. 40	N/A- existing pipe is abandoned					
422P-CSBC	Cole South Branch No. 40	N/A- existing pipe. 30% replacement design specified in Table A-1					No
451C-DCCa	Dry Creek Canal No. 75	Topography and aerial	FIS Water surface profile (FEMA 2009a)	Peak flow of 500 cfs	N/A	100-yr profile = ~286.0 feet NAVD 88 from at the HST crossing (FEMA 2009a, panel 15)	Modeling – HEC-RAS Complete

C2 FID Requirements

FID will require the Engineer to perform hydraulic calculations to determine the necessary pipe, culvert, or bridge dimensions for each canal crossing unless the canal has already been master-planned by FID. The calculations will help determine water surface profile impacts and the amount of head loss across the culvert. New culvert structures cannot raise upstream water levels above current levels.

C2.1 Small/Medium Canal Crossing Requirements

The majority of the proposed crossings will impact existing pipelines and small open channel canals. Requirements for the pipelines will include:

- All new pipelines will be ASTM C-361 Rubber Gasket Reinforced Concrete Pipe (RGRCP). FID typically requires a minimum of three feet of cover over pipelines. FID tries to eliminate siphons wherever possible due to sedimentation, plugging, and trash removal issues.

- FID is also concerned that some of its pipelines that fall outside HST ROW and Road ROW could be damaged during construction. FID anticipates the use of large, heavy equipment during construction that could easily damage FID's older pipelines, especially where there is shallow cover and/or non-reinforced concrete pipe.

C2.2 Large Canal Crossing Requirements:

There are several large canal crossings that will not be able to be contained within a pipeline such as the Herndon Canal and Dry Creek Canal. The design shall protect the canal's integrity for an urban setting. The proposed canal crossing must be designed to convey the water in a safe and efficient manner without altering the existing conditions in a negative manner in regards to FID's operation and maintenance. Additional requirements will include:

- FID requires a minimum freeboard of 2.0 feet through the canal crossing, where possible. The freeboard is needed to pass floating debris and trash through the structure.

- FID prefers that the crossing be a clear span bridge with no obstructions within the canal. If a multiple bay culvert or a bridge with pilings design is selected, trash and debris will collect on the piers and culvert walls. Access must be provided to remove the trash in a safe and efficient manner. Additional property or easement maybe required if it is determined that more trash will collect due to the canal crossing. Maintenance accessibility for trash removal needs to be evaluated based on channel size, amount of trash collected at location in question and accessibility. A galvanized steel or concrete catwalk will be required on the upstream side of the bridge/culvert structure.

- The large canals are typically dredged every 3-5 years depending on the location and the sedimentation carried in that particular canal. FID crews typically remove the sediment with bulldozers in the channel and use large excavators for removing the sediment and depositing the spoils on top of the banks to dry out. Once the spoil has dried, FID will flatten the spoil as time permits. If necessary, FID will remove the spoils and haul them away in a dump truck. With this in mind, FID will need adequate room to load the trucks as well as to pull a semi-truck and trailer loaded with equipment off the road and onto its canal banks.

- In most cases, the culvert should extend past the HST ROW where FID's equipment can safely access both banks for operations and maintenance purposes. The length that the culvert should extend depends on the type of equipment needed to access both banks. The culvert should extend a minimum of 20 feet to allow access for FID's Water System Operator vehicles (1/2 ton trucks) and spray truck (1 ton). Some crossings may need to be extended for larger equipment such as an excavator.

- In some situations, turnaround areas may need to be constructed for FID's O&M equipment. Turnaround areas may need to be significantly long and wide to handle the large trucks and equipment.
- Gaps between bridges – FID will not allow small gaps between bridges and culverts.

As part of the project, the bridge/culvert will transition back to the open canal and the following are a few guidelines and requirements:

- Required canal improvements will include reshaping the canal and slope stabilization. FID recommends dredging the canal, placing the dredgings off to the side of the canal, where feasible, and compacting to a minimum of 93 percent of maximum density.
- All disturbed areas of a canal must be restored with concrete lining (both side slopes and bottom). FID will require structurally reinforced concrete to limit the on-going maintenance that typically occurs with gunite or shotcrete slope protection.
- Drive surfaces must be sloped a min of 2% away from the canal with provisions made for rainfall. Drainage will not be accepted into the Canal and must be routed away from FID property/drive banks. Runoff must be conveyed to nearby public streets or drainage systems by drainage swales or other FID acceptable alternatives.
- Drive surfaces shall be overlaid with 3 inches of Class 2 aggregate base course for all-weather access.
- All existing trees, bushes, debris, old canal structures, pumps, canal gates, and other non- or in-active FID and private structures must be removed within FID's property/easement.
- FID requires a minimum of 1.5 feet of freeboard and a maximum of 2 feet.

C3 Hydraulic Structures Geometry

C3.1 Herndon Canal

At Herndon canal, the HST alignment roughly corresponds with the current alignment of Golden State Boulevard (GSB). GSB will be relocated adjacent to the HST on its western side, and new bridges will be built for both the HST and GSB. The channel will be lined with concrete beneath the bridges. The HST conceptual bridge design includes a single pier and sloped concrete abutments, and the GSB conceptual bridge design includes a single-span without any piers and sloped concrete abutments.

Surveyors measured and defined the existing geometry for bridges and hydraulic structures in the modeled reach of Herndon Canal. The dominant downstream control is located about 4,500 feet downstream of GSB. It consists of an in-line stoplog weir with an integral 42-foot-long by 7-foot-wide box weir extending upstream in the center of the channel. There are also six bridges in the model: The existing 3-span UPPR bridge upstream of GSB, the existing 5-span GSB bridge to be replaced by the 2-span HST bridge, the new single-span GSB bridge, the 2-span north-bound and south-bound SR 99 bridges, and a 3-span grated catwalk structure. Photos of each structure are included as Exhibit C-1.

Exhibit C-1. Hydraulic Structures along Herndon Canal.

Typical channel section, looking upstream (east) from UPRR Bridge.

UPRR Bridge, looking downstream.

Existing GSB Bridge, looking downstream from the UPRR Bridge.

Typical channel section, looking downstream toward north-bound SR 99 Bridge.

South-bound SR 99 bridge, looking downstream. The central pier is continuous for the two bridges.

Grated catwalk structure, looking downstream.

Downstream control: integral box weir and in-line stoplog structure.

Bridges were modeled according to their surveyed geometry. The box-weir downstream was modeled as two 49-foot-long lateral weirs, and the channel cross sections along the weir were modified to block downstream flow from the area of the box. The stoplog weir was modeled as an inline-weir at the downstream end of the lateral weirs. The flow over all weirs were returned downstream. The complexity of this geometry made it necessary to use dynamic flow routing in HEC-RAS to capture the flow and depth reduction along the length of the lateral weirs and at the in-line stoplogs.

C3.2 Dry Creek Canal

The HST alignment crosses Dry Creek Canal near where the San Joaquin Valley Railroad (SJVRR) currently crosses the Dry Creek Canal. The HST alignment will pass beneath the canal and the SJVRR requiring both to be conveyed over the HST alignment in new structures. The HST conceptual bridge for Dry Creek Canal design includes a single pier and sloped concrete abutments.

The existing geometry for bridges and hydraulic structures in the modeled reach of Dry Creek Canal was derived from the base project survey mapping. There are also four existing bridges in the model: The existing North Thorne Avenue Bridge (Canal Station 113), SJVRR (Canal Station 1608), UPRR (Canal Station 1803), and North H Street (Canal Station 1995). Bridges were modeled according to their estimated geometry. Photos of each structure are included as Exhibit C-2.

Exhibit C-2. Hydraulic Structures along Dry Creek Canal.

Existing North Thorne Avenue Bridge, looking upstream (northeast).

Existing SJVRR Bridge, looking downstream (southwest).

Existing UPRR Bridge, looking upstream (northeast).

Existing North H Street, looking upstream (northeast).

C4 Cross Sections

C4.1 Herndon Canal

Twenty-three cross sections were surveyed along Herndon Canal, including sections immediately upstream and downstream of hydraulic structures. The cross section locations are shown on Exhibit C-3. Survey data included channel geometry, hydraulic structure geometry, water surface elevations and historical high water marks.

Exhibit C-3. Location of Cross Sections for Herndon Canal HEC-RAS model.

C4.2 Dry Creek Canal

Forty-six cross sections were developed for the Dry Creek Canal model, including sections immediately upstream and downstream of hydraulic structures. These sections were developed from the base survey mapping for the project design. No new survey was carried out. The cross section locations are shown on Exhibit C-4 and Figure C-2.

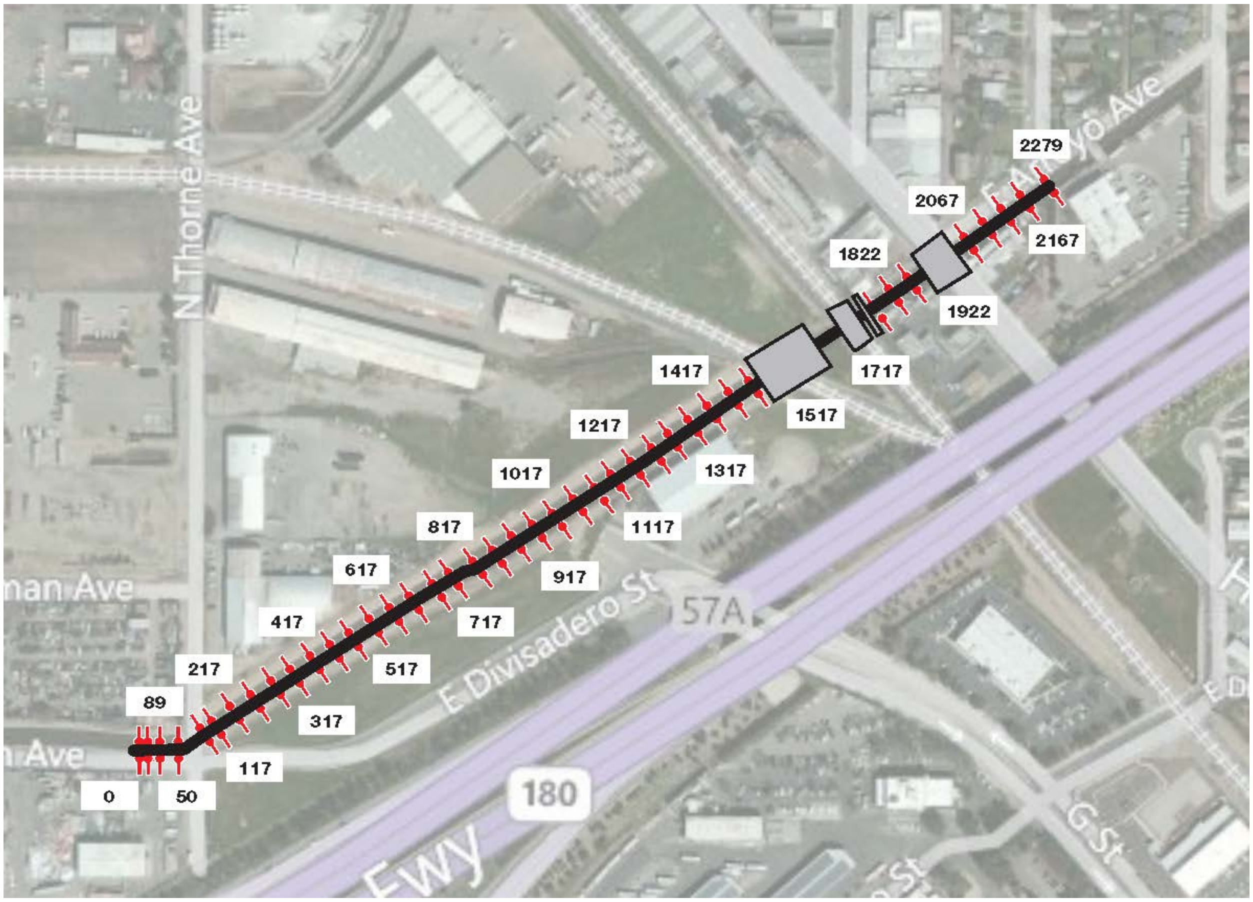


Exhibit C-4. Location of Cross Sections for Herndon Canal HEC-RAS model.

C5 Rating Tables

Rating tables were not used for hydraulic design in Procurement Package 1.

C6 Model Boundary Conditions

C6.1 Herndon Canal

Normal depth based on channel slope was used as the downstream boundary in the Herndon Canal model, but the effective control was the length and discharge coefficient for the downstream weirs.

The upstream boundary condition was an input hydrograph with a peak flow rate matching the flow to be evaluated.

C6.2 Dry Creek Canal

Normal depth based on channel slope was used as the downstream boundary in the Dry Creek Canal model, but the effective control was the UPRR and SJVRR bridges.

The upstream boundary condition was an input hydrograph with a peak flow rate matching the maximum flows reported by the FID.

C7 Calibration or Roughness (Manning's "n")

C7.1 Herndon Canal

The Herndon Canal HEC-RAS model was calibrated by adjusting weir coefficients and channel roughness so that flow depths approximated the relatively low flow at the time of the survey, the approximate high flow that produced high-water marks, and the 100-year water surface profile at the GSB Bridge obtained from the Fresno County FIS (FEMA 2009a). The 0.7-foot wide box weir was modeled as narrow broad-crested lateral weirs with a coefficient of discharge of 3.1, and the stoplogs were modeled as sharp-crested overflow gates with a coefficient of discharge of 3.3. Model calibration was limited to cross sections upstream of the weirs. A calibrated channel roughness n-value of 0.023 was used throughout the model, except for 0.025 to maintain subcritical flow between the UPRR and GSB bridges. The relatively low Manning's "n" represents uniform canal conditions with clean slopes and channel bottom. Lower Manning's "n" generally caused aberrant model results.

Model and calibration results are summarized in Table C-2. When there were two water surface elevations at a cross section, the higher value was conservatively selected. FID estimated the flow rates on the days of the survey as 129 cfs and 149 cfs, with some minor additional flow possible that was not measured. This unspecified additional flow was neglected. Comparing model results in Columns 8 and 9 to surveyed water surface elevations in Column 7 indicate good agreement for this flow range, with differences in modeled versus surveyed water surface elevations generally less than 0.1 feet. A comparison of Column 15 model results to measured high water marks in Column 13 shows variability in agreement, stemming largely from greater uncertainty and incongruence in high water marks. The highest flow rate in the last 8 years was measured by FID as 444 cfs, and the highest flow rate in the past 20 years was 550 cfs, equivalent to the estimated 100-year flow rate. The agreement between surveyed, FEMA and modeled water surface elevations for 550 cfs was within 0.1 feet immediately upstream of GSB. Model calibration was considered adequate for use in modeling the 600 cfs design flow rate.

Table C-2
Inventory of Hydraulic Information – UPRR/SR 99 Alternative

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
			Edge of Water when Surveyed						High Water Mark when Surveyed						Design Elevation (ft) for Design Flow of 600 cfs		
			Elevation (ft)				Calibration		Elevation (ft)				Calibration				
Model Section	Surveyed Section	Survey Date	Left	Right	Differ-ence	Max	Model 129 cfs	Model 149 cfs	Left	Right	Differ-ence	Max	FEMA FIS Profile (550 cfs)	Model 550 cfs	Existing	Design	Incre-ment
5355.7	1	Aug. 30	301.20	301.10	0.10	301.20	301.23	N/A	302.50	302.70	0.20	302.70		302.92	303.1	303.06	-0.04
4711.4	2	Aug. 30	301.10	300.90	0.20	301.10	301.16	N/A	302.30	302.30	0.00	302.30		302.76	302.93	302.88	-0.05
4635.5	3	Aug. 30	301.10	301.10	0.00	301.10	301.14	N/A	302.30	302.00	*0.30*	302.30		302.67	302.84	302.79	-0.05
4625	Bridge	Aug. 30	(UPRR)					N/A									
4604	4	Aug. 30	----	----	----	----	301.14	N/A	----	----	----	----		302.64	302.8	302.75	-0.05
4581.3	5	Aug. 30	300.90	301.10	0.20	301.10	301.13	N/A	302.70	302.50	0.20	302.70	302.6	302.64	302.81	302.75	-0.06
4549.2	6	Aug. 30	----	----	----	----	301.13	N/A	----	----	----	----		302.64	302.8	302.74	-0.06
4549	Bridge	Aug. 30	(Existing Golden State Boulevard/Design HST Bridge)														
4478.5	7	Aug. 30	----	----	----	----	301.13	N/A	----	----	----	----		302.60	302.76	302.76	0
4445.0	8	Aug. 31	301.10	300.90	0.20	301.10	N/A	301.21	302.10	302.20	0.10	302.20	302.4	302.61	302.77	302.77	0
4444	Bridge	Aug. 31	(Design Golden State Boulevard)				N/A	N/A	N/A	N/A	N/A	N/A		N/A	N/A		N/A
4387.0	Added	Aug. 31	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A	N/A	302.77	N/A
4345.8	9	Aug. 31	301.10	301.10	0.00	301.10	N/A	301.21	302.10	302.10	0.00	302.10		302.61	302.77	302.77	0
4185.8	10	Aug. 31	301.10	301.10	0.00	301.10	N/A	301.20	302.00	302.30	*0.30*	302.30		302.56	302.72	302.72	0
3616.2	11	Aug. 31	301.10	301.00	0.10	301.10	N/A	301.19	302.00	301.80	0.20	302.00		302.49	302.64	302.64	0
2847.4	12	Aug. 31	301.10	301.10	0.00	301.10	N/A	301.16	301.90	302.30	*0.40*	302.30		302.33	302.46	302.46	0
2752.5	13	Aug. 31	301.10	301.10	0.00	301.10	N/A	301.16	301.70	301.90	0.20	301.90		302.32	302.46	302.46	0
2752	Bridge	Aug. 31	(SR 99 North)				N/A										
2605.5	14	Aug. 31	301.10	301.20	0.10	301.20	N/A	301.15	301.70	301.80	0.10	301.80		302.27	302.4	302.4	0
2581.7	15	Aug. 31	301.20	301.10	0.10	301.20	N/A	301.15	301.70	302.80	*1.10*	302.80		302.25	302.37	302.37	0
2581	Bridge	Aug. 31	(SR 99 South)				N/A										
2512.2	16	Aug. 31	301.20	301.10	0.10	301.20	N/A	301.15	301.70	302.30	*0.60*	302.30		302.23	302.36	302.36	0
2401.7	17	Aug. 31	301.10	300.90	0.20	301.10	N/A	301.14	301.80	301.60	0.20	301.80		302.22	302.34	302.34	0
1684.3	Added	Aug. 31	----	----	----	----	N/A	301.12	----	----	----	----		302.03	302.13	302.13	0
1654.3	18	Aug. 31	301.10	301.10	0.00	301.10	N/A	301.11	301.80	301.90	0.10	301.90		302.02	302.12	302.12	0
1654	Bridge	Aug. 31	(Catwalk)				N/A										
1644.3	Added	Aug. 31	----	----	----	----	N/A	301.11	----	----	----	----		302	302.09	302.09	0
1614.3	Added	Aug. 31	----	----	----	----	N/A	301.11	----	----	----	----		301.99	302.08	302.08	0
1431.6	19	Aug. 31	301.20	301.00	0.20	301.20	N/A	301.11	301.50	301.60	0.10	301.60		301.98	302.07	302.07	0
272.1	20	Aug. 31	301.00	301.00	0.00	301.00	N/A	301.08	301.50	301.80	*0.30*	301.80		301.78	301.84	301.84	0
110.7	Added	Aug. 31	----	----	----	----	N/A	301.08	----	----	----	----		301.77	301.83	301.83	0
110	Lat Struct	Aug. 31	(Lateral weir - key weir)				N/A										
109	Lat Struct	Aug. 31	(Lateral weir - key weir)				N/A										
103.7	21	Aug. 31	301.10	----	0.00	301.10	N/A	301.08	301.50	----	0.00	301.50		301.73	301.79	301.79	0
61.7	22	Aug. 31	----	----	----	----	N/A	301.1	----	----	----	----		301.95	302.04	302.04	0
61	Inl Struct	Aug. 32	(In-Line Stoplogs)				N/A										
0	23	Aug. 31	298.70	298.80	0.10	298.80	N/A	296.01	300.20	300.30	0.10	300.30		297.77	297.94	297.94	0
-100	Added	Aug. 31	----	----	----	----	N/A	295.25	----	----	----	----		296.31	296.42	296.42	0

C7.2 Dry Creek Canal

Insufficient data was available to calibrate the Dry Creek Canal model. FID had confirmed that the maximum recorded flow was approximately 500 cfs within Dry Creek Canal and that this flow is contained within the Dry Creek Canal channel. In the model the channel roughness coefficients were adjusted to reflect this information, keeping the maximum flow reported by FID just within the channel.

C8 Design Flow

The design flows used in the hydraulic models were 600 cfs for the Herndon Canal and 500 cfs for the Dry Creek Canal, are as summarized in Appendix B, Table B-1.

C9 Concurrent Conditions

Concurrent conditions, which include model inputs such as downstream tributary inflow and elevation of a reservoir pool at the start of flooding, were not analyzed or pertinent for Herndon Canal and Dry Creek Canal.

C10 Design Water Surface Elevation (WSE)

C10.1 Herndon Canal

At Herndon Canal, Table C-2 indicates a design water surface elevation of 302.8 feet for both new bridges.

C10.2 Dry Creek Canal

A HEC-RAS model was developed to compare the existing Dry Creek Canal maximum flow conditions against the proposed improvements to the Dry Creek Canal at the alignment crossing and North Thorne Avenue.

C11 Incremental Rise and Velocity

C11.1 Herndon Canal

Column 18 of Table C-2 and Figure C-2 show that the proposed improvements do not raise the peak water surface elevation of Herndon Canal. In general, the water surface elevation is lowered upstream of the new HST bridge (Figure C-1) because the current 5-span bridge with minimal freeboard would be replaced by a 2-span bridge with adequate freeboard. The new GSB bridge is a single span, and does not adversely impact the channel capacity.

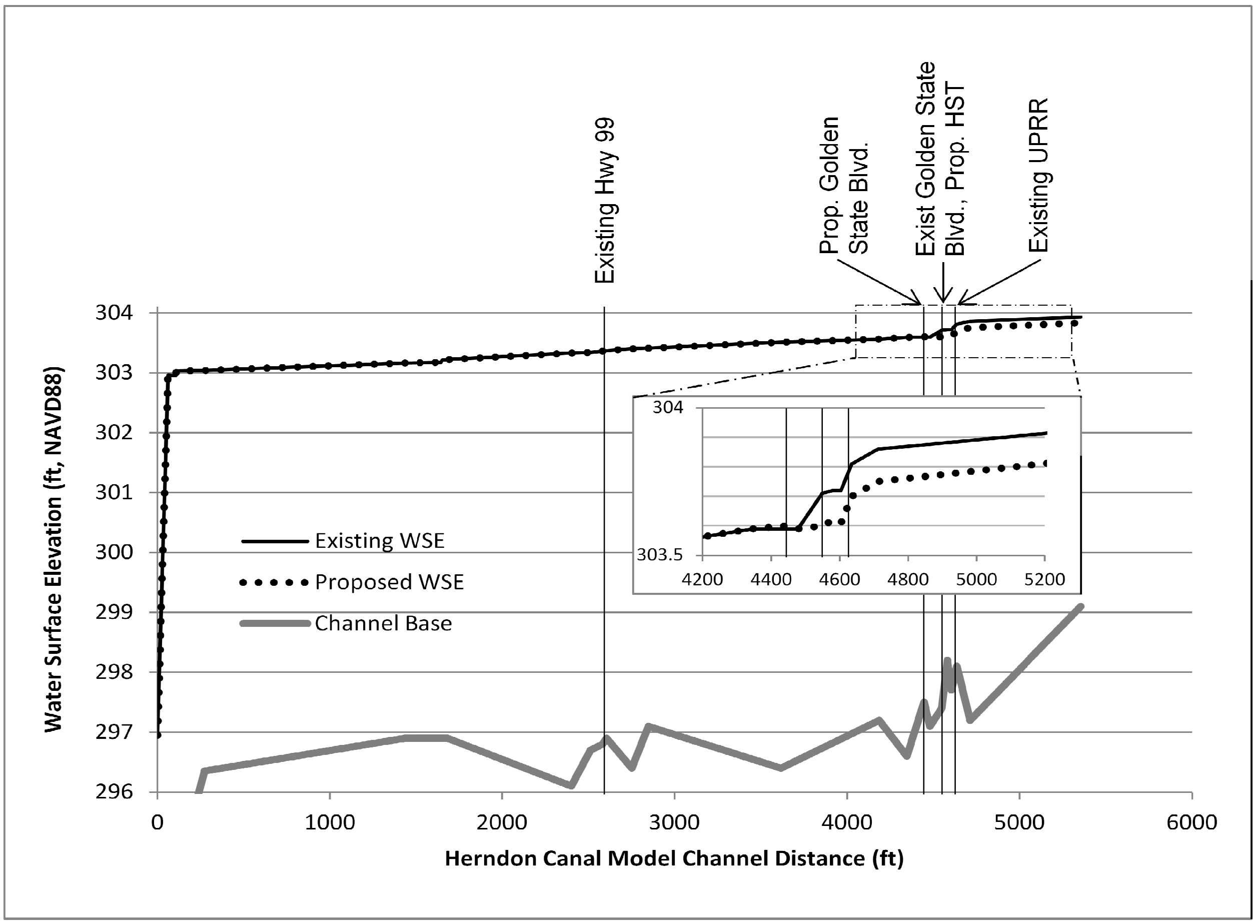


Figure C-1
Herndon Canal HEC-RAS Water Surface Profiles

C11.2 Dry Creek Canal

Figure C-2 shows that the proposed modifications significantly improve the water surface elevation at the HST crossing compared to the existing conditions (Canal Station 1,762 ft) and cause no impact at North Thorne Avenue (Canal Station 113). Note that it is assumed that the replacement bridge at North Thorne for roadway improvements will be a replacement in kind.

The proposed WSE at Canal Station 1,600 increases in the model by approximately 0.1 feet above the existing WSE. The low chord of the existing SJVRR bridge (approximately Canal Station 1,600) is constraining the flow and artificially lowering the existing WSE (see Exhibit C-2). The SJVRR bridge will be replaced, slightly raising the low chord of the new bridge and reducing, although not eliminating, the exiting constriction.

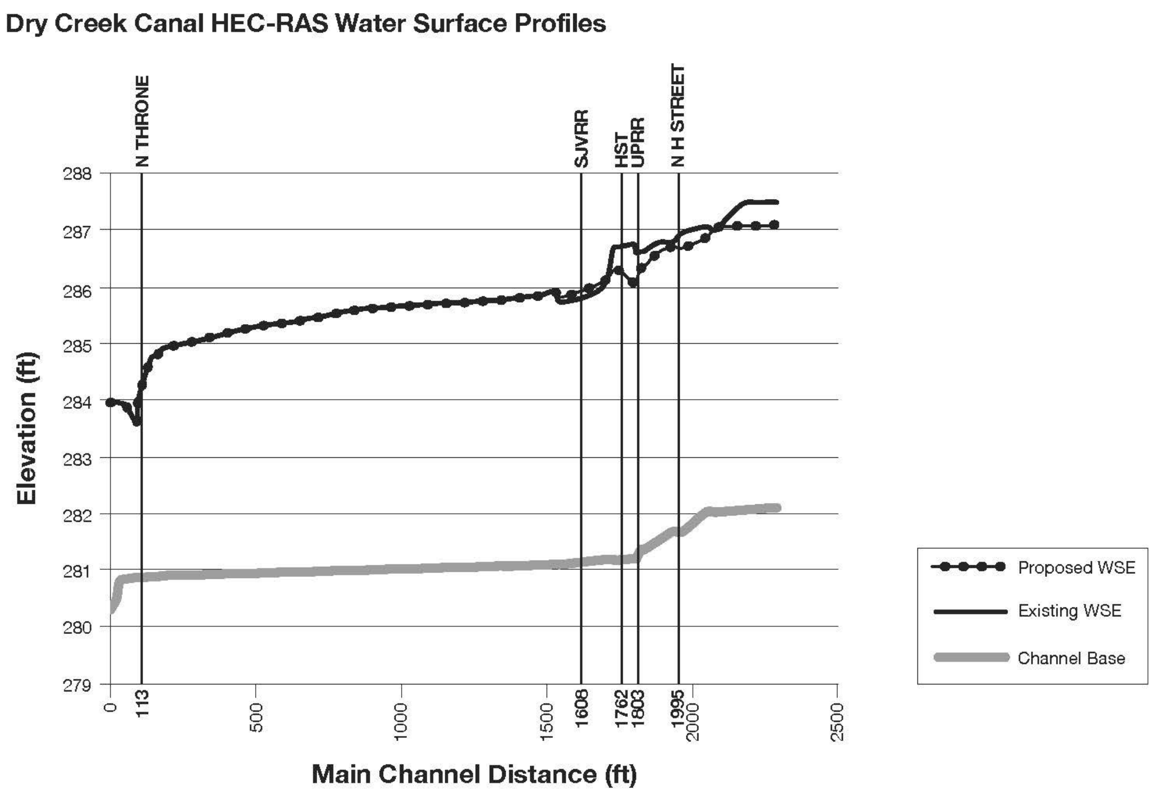


Figure C-2
Dry Creek Canal HEC-RAS Water Surface Profiles